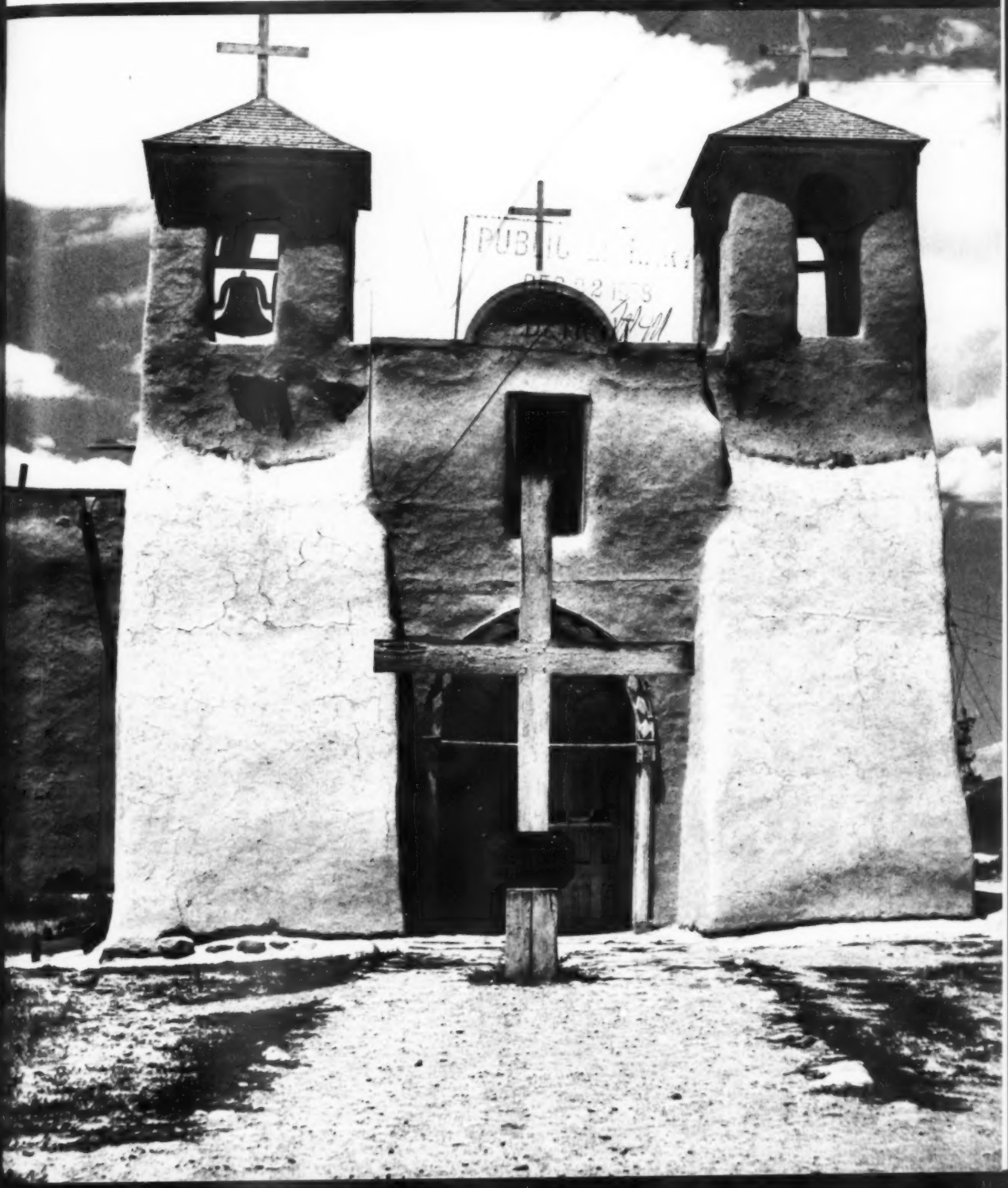
TECHNOLOGY DEPT.

TECHNOLOGY REVIEW

December 1958



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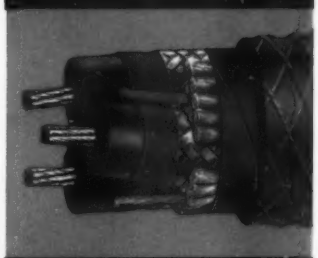

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Stratton Elected President of M.I.T.
Killian Becomes Chairman of Corporation
Bush Takes New Post as Honorary Chairman

ACTING on the recommendation of James R. Killian, Jr., President of the Massachusetts Institute of Technology since 1948, the M.I.T. Corporation appointed Julius A. Stratton, now Chancellor and Acting President, to be the next President of the Institute, effective January 1, 1959.

Dr. Killian, who continues on leave as Special Assistant to President Eisenhower, was at the same time elected Chairman of the Corporation, a post to which he will devote full time when he returns in the future from his service in Washington.

Vannevar Bush, who has served as Chairman of the Corporation for the past two years, was elected Honorary Chairman of the Corporation.

The elections, confirming recommendations presented by its Executive Committee, were made at the regular meeting of the Corporation on December 1, and announced at a special convocation of the Faculty following the meeting of the Corporation.

In commenting on Dr. Stratton's appointment as President and Dr. Killian's election as Chairman of the Corporation, Dr. Bush said:

"Last October Dr. Killian suggested to the Corporation, as he had earlier done to members of its Executive Committee, that because of his continuing leave status and other considerations he wished to relinquish the Presidency of the Institute whenever a successor could be appointed. The Corporation, in response, indicated its conviction that the Institute now has indispensable need for two full-time senior officers, the Chairman of the Corporation and the President as Chief Executive Officer. The Corporation also suggested that it proceed to appoint a new President and that when Dr. Killian returned from his leave in Washington he come back as full-time Chairman of the Corporation, a post that would enable him to concentrate on those aspects of the Institute's program that look outward rather than inward and that would be concerned with the over-all trustee policy and to share with the President the formulation of institutional goals.

"In seeking a new President of the Institute, the Corporation and its Executive Committee consulted with senior representatives of the Faculty and of the Alumni Association. We came enthusiastically and unanimously to the conclusion that Dr. Stratton was superbly qualified to succeed Dr. Killian as President, that he would have the enthusiastic support of the M.I.T. community, and that the Institute would be fortunate if Dr. Stratton would accept an invitation to serve as President. I am very happy that he has accepted the appointment.

"The Corporation, in electing Dr. Killian as Chairman, granted him leave of absence in this new post in recognition of his continuing important responsibilities in Washington, but in so doing, reaffirmed the urgent need for Dr. Killian to return to the Institute in order to assume his new duties full time at the earliest appropriate date."

In commenting on Dr. Stratton's election to the Presidency of the Institute, Dr. Killian said:

"Dr. Stratton's election recognizes his immense contributions to M.I.T. and his leadership in science and education, both at M.I.T. and nationally. He possesses to an extraordinary degree those qualities of mind, and character, and spirit, which are required for an outstanding academic administrator and specifically for the Presidency of M.I.T.

"Dr. Stratton and I have long worked together with a sense of common purpose and extraordinary concert on policy. In this fortunate fact lies the best assurance that the new administrative arrangements will work happily and well. One of the principal responsibilities of a chief executive is to set the stage for succession, to insure future leadership of the highest possible caliber for the institution. I am happy and confident that this has been done.

"I am confident of his success as President and of the loyal support of his colleagues, as I am grateful to him and to them for their generous cooperation with me during the eighteen years that I have carried major responsibilities in connection with the M.I.T. President's Office, ten of them as President.

"For some months it has been my plan and conviction that, if agreeable, I would like, at an appropriate time, to shift to the Chairmanship of the Corporation, following the precedent of Dr. Karl Taylor Compton, who became Chairman when he went to Washington in 1948 as Chairman of the Research and Development Board of the Department of Defense, and I became President. My continuance on a leave status, and the availability of Dr. Stratton, make this change appropriate now and assure that there be no loss of momentum in the administration of the Institute because of my leave.

"As Chairman of the Corporation I can serve the Institute in a way that will draw most effectively on my experience and afford me special opportunities to do all within my power further to promote the usefulness of this institution, especially to help secure for it those additional resources and facilities its great and growing responsibilities so urgently require."

Dr. Killian's present assignment is one of international significance and is bound to have beneficial effect when he returns to the Institute.

Dr. Stratton has the Review's best wishes, wholehearted cooperation, and sympathetic understanding as he becomes the eleventh President of M.I.T.

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SHOCK:	Up to 60 G
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THE TECHNOLOGY REVIEW, December, 1958, Vol. LXI, No. 2. Published monthly from November to July inclusive at Emmett Street, Bristol, Conn. Publication date: twenty-seventh of the month preceding date of issue. Annual subscription, $4.00: Canadian and Foreign subscription, $4.50. Entered as second-class matter December 23, 1949, at the Post Office, at Bristol, Conn., under the Act of March 3, 1879.

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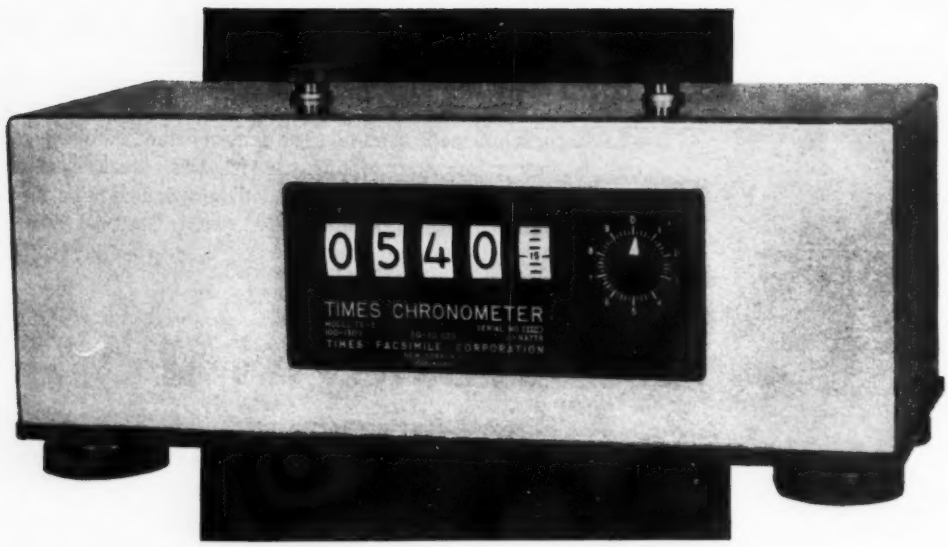

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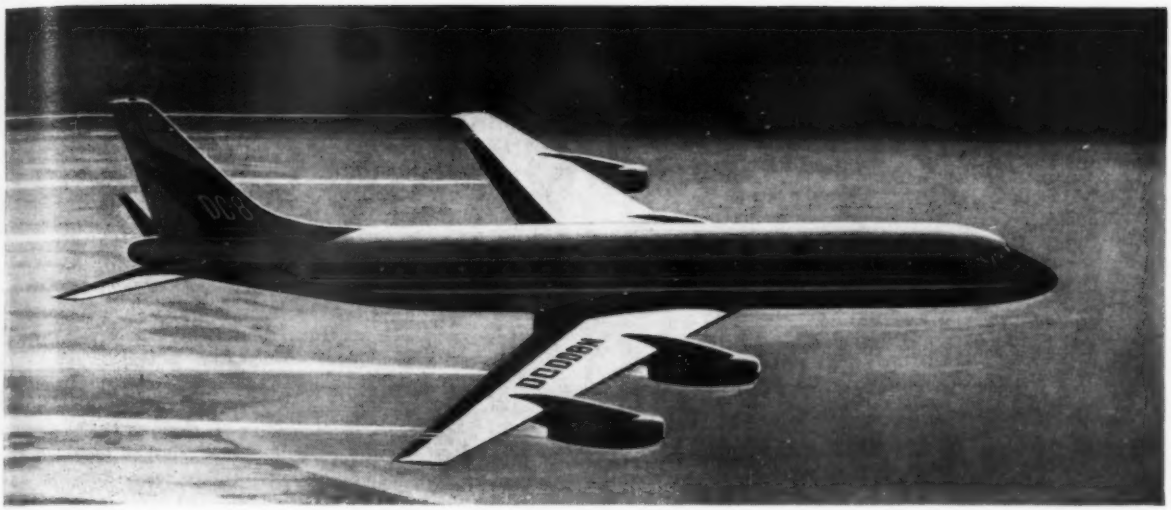

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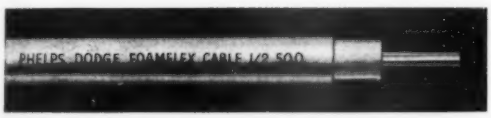

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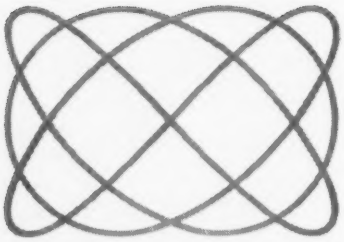

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THE TABULAR VIEW

Learning by Doing.—A co-operative program for leading students in geophysics is described (page 83) by ROBERT R. SHROCK, Head of the Institute's Department of Geology and Geophysics. This program, initiated in 1951 by Professor Shrock and Cecil H. Green, '23, is a modern example of the William Barton Rogers' philosophy of combining theoretical studies with practical application. During the first summer program managed by Geophysical Service, Inc., all students came from M.I.T. However, the co-operative program proved to be so successful that other colleges clamored for opportunity to participate, and nationwide support came from other firms engaged in geophysics or related activities.

A native of Indiana, Professor Shrock received the A.B., A.M., and Ph.D. degrees in geology from the University of Indiana in 1925, 1926, and 1928, respectively. He taught at the University of Wisconsin from 1928 until 1937 when he joined the M.I.T. Faculty as assistant professor. He became associate professor in 1943, was promoted to full professor in 1949, and that year became head of the Department of Geology. He is consultant for various mining, petroleum, and engineering companies, museums, and state geological surveys. He conducted important geological field studies in Haiti, the Dominican Republic, Cuba, Jamaica, and Mexico, as well as in the United States. Dr. Shrock is also widely known for his contributions to the literature of geology. He is author of many technical papers and books, including *Invertebrate Paleontology* (with William H. Twenhofel), *Index Fossils of North America* (with Hervey W. Shimer), and *Sequence in Layered Rocks*.

Professor Shrock gives much credit for the establishment of the co-operative course for geophysicists to Dr. Green. Dr. Green is a graduate of the Institute's Co-operative Course in the Department of Electrical Engineering. He is president of Geophysical Service, Inc., a director of Texas Instruments, Inc., and is a special term member of the M.I.T. Corporation.

Life Is Colorful.—Whether the observed coloration is due to the scattering or interference of light, or whether it is attributable to pigments within the living substance, color plays a persistent and important role in nature. In fact, as FREDERIC W. NORDSIEK, '31, notes in "Life Is Colorful" (page 89) nowhere else do beauty and utility so closely intermingle as in the colors of the living world, and without its myriad colors, life would not be merely dull—it would be impossible. If the green of chlorophyll is the characteristic color of the plant world, then the red of hemoglobin is the primary color of the animal world; for all of the vertebrates — and many lower animals—have blood containing the red pigment of hemoglobin, although a few sea animals are "blue bloods." In many cases, the protective coloring of animals may be a lifesaver in making them inconspicuous to their enemies; in other instances, however, colors and their patterns play a significant role in courtship, and hence in survival of the species.

A native of New York Mr. Nordsiek received the S.B. degree in Biology and Public Health from M.I.T. in 1931. Since then he has had wide experience in research and administration in the food industry and in public health activities. From 1943 to 1951, he was assistant director, Research Service Department of Standard Brands, Inc. Since 1951 he has been associated with the American

(Concluded on page 70)

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THE TABULAR VIEW

(*Concluded from page 68*)

Cancer Society. His work deals with organizing and administering research grants programs.

Mr. Nordsiek has been an editorial associate of The Review since 1944, for which he has written more than 100 feature articles and unsigned shorter pieces. In addition, articles by him have appeared in such publications as *Encyclopaedia Britannica* year books, *Encyclopedia Americana, Science Digest, American Journal of Public Health, Appalachia, Nature Magazine, and Food Engineering.*

Conquest of Typhus Fever. – From time to time in past issues of The Review, JAMES A. TOBEY, '15, has discussed the role which various diseases and epidemics have played in changing the course of history. Dr. Tobey's discussion in this issue (page 93) deals with the conquest of typhus fever. Of particular significance to Review readers is his mention of the serious epidemic of typhus fever which raged in Serbia in 1915, and which was finally brought under control through efforts of the American Red Cross Sanitary Commission to Serbia. More than half of the members of this Commission were Technology Alumni who had either studied bacteriology or sanitary engineering at the Institute, or had been graduated from the Harvard-Technology School for Health Officers. Among the members of this Commission was Dr. Stanley H. Osborn, '15, through whose co-operation The Review is happy to be able to publish the illustration of the members of this Commission as they were about to leave New York.

A native of Quincy, Mass., Dr. Tobey attended Roxbury Latin School, and came to M.I.T. where he received the S.B. degree in 1916. He received an LL.B. degree from Washington Law School in 1922, an M.S. from American University in 1923, the Dr. P.H. degree from M.I.T. in 1927, and the LL.D. from Southeastern University in 1938. His professional life has been spent in advancing public health and laws affecting it. He has lectured at M.I.T., Yale, Harvard, and Columbia, and has served in the Army's Medical Service. Colonel Tobey has written more than 100 articles, about 20 pamphlets, many books, and numerous Review articles.

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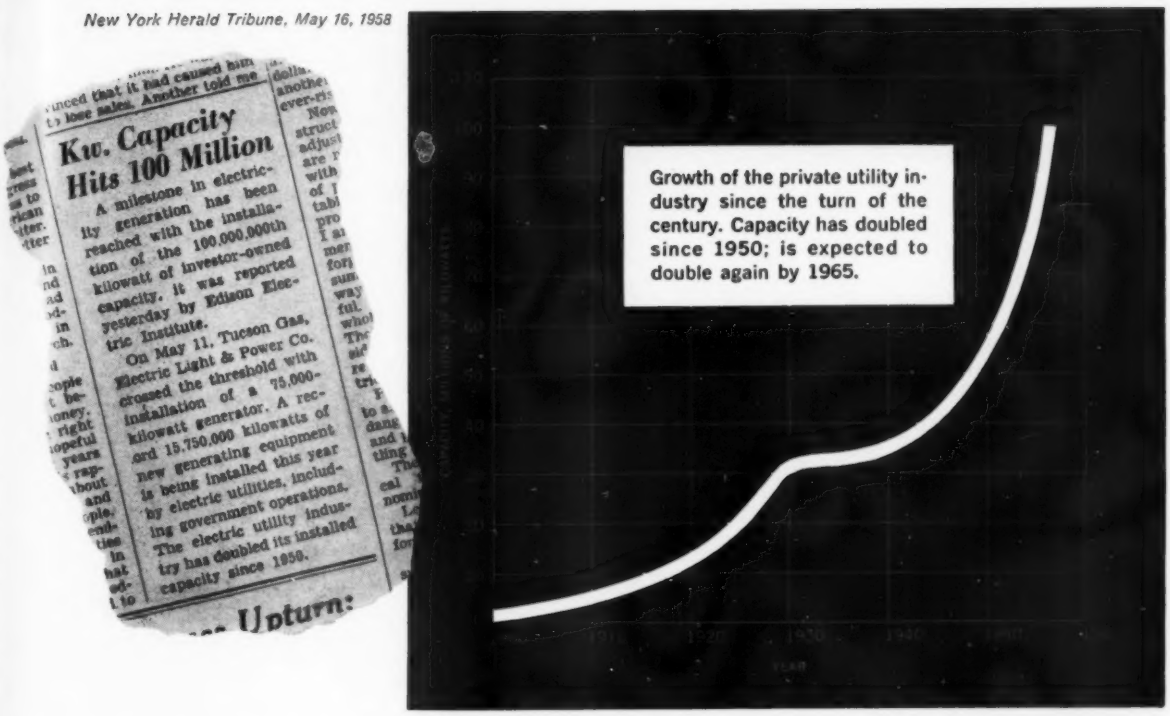
New York Herald Tribune, May 16, 1958
Kw. Capacity Hits 100 Million
A milestone in electricity generation has been reached with the installation of the 100,000,000th kilowatt of investor-owned capacity, it was reported yesterday by Edison Electric Institute.
On May 11, Tucson Gas, Electric Light & Power Co. crossed the threshold with installation of a 75,000-kilowatt generator. A record 15,750,000 kilowatts of new generating equipment is being installed this year by electric utilities, including government operations. The electric utility industry has doubled its installed capacity since 1950.
Upturn:
Growth of the private utility industry since the turn of the century. Capacity has doubled since 1950; is expected to double again by 1965.

A major milestone in America's march toward

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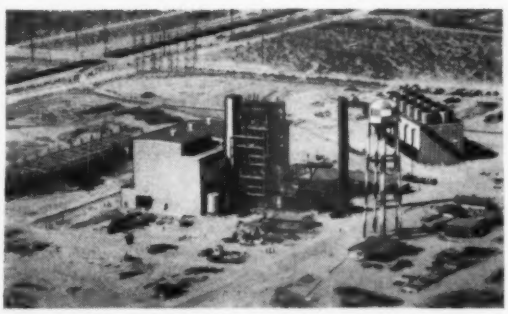

POWERED BY A C-E BOILER, this is the plant that brought the utility industry across the 100,000,000-kw threshold. It's the 75,000-kw Plant No. 4, Tucson Gas, Electric Light & Power Co., Tucson, Ariz. (Sanderson & Porter, Consulting Engineers)

Continuing their remarkable expansion of electrical generating capacity, America's investor-owned utility companies reached, in May, the significant landmark of 100,000,000 kilowatts. That's about double the capacity – privately and publicly owned – of any other country in the world.

Growth like this puts real meaning in the words "Live Better ... Electrically." For example, it means the average American housewife today has the electrical equivalent of many servants helping her to do her housework ... the average factory worker has the equivalent of 367 helpers. Thus, the utility industry, in its constant drive to provide *more power for more people,* has had perhaps the greatest single share of the job of assuring a steady rise in the standard of living in this country.

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As the utility industry heads toward its second hundred-million kilowatts, Combustion Engineering congratulates it for its vital role in making America ever more productive and prosperous.

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THE TECHNOLOGY REVIEW

EDITED AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

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Relating to the Massachusetts Institute of Technology

New England Scene

Although made in Sudbury, Mass., this photograph by Raymond E. Hanson reflects the yearning for peace that traditionally marks the Christmas season.

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Modern Symbol

Photographed by F. S. Lincoln, '22, in the T.W.A. Service Building of New York's Idlewild Airport, this scene of tail section of modern air transport is symbolic of man's desire to travel ever more swiftly.

The Technology Review

VOL. 61, NO. 2 DECEMBER, 1958

The Trend of Affairs

Shannon Appointed Donner Professor

■ Appointment of Claude E. Shannon, '40, leading scientist and pioneer in the development of information theory, to the recently established Donner Chair of Science at the Institute was announced recently by J. A . Stratton, '23, Acting President.

As reported under the title "Grant for Chair in Physical Science" (page 469, July, 1958, Technology Review), the new professorship was made possible by a $500,000 grant from the Donner Foundation of Philadelphia, the largest ever received by M.I.T. for endowment of an academic chair.

The 42-year-old native of Gaylord, Mich., received his undergraduate degree at the University of Michigan in 1936, and was awarded an S.M. in Electrical Engineering and a Ph.D. in Mathematics from M.I.T. in 1940. In 1941 he became a research mathematician with the Bell Telephone Laboratories in Murray Hill, N.J., specializing in research on communication theory and computing machines and automata.

In January, 1956, Dr. Shannon was granted a leave of absence from the Bell Telephone Laboratories and returned to M.I.T. as a visiting professor of electrical communications. In 1957 he joined the Institute Faculty as a permanent member, with the dual title of professor of communications sciences in the Department of Electrical Engineering and professor of mathematics.

The field in which the newly honored professor has achieved special eminence is that of information theory, a branch of science which combines methods of mathematics and electrical communications in computing, automation, and areas of the behavioral sciences that bear on the relation of man to his environment. Dr. Shannon's work in this field has had practical applications in automatic telephone systems, and improved systems by which information is coded for transmission.

Among honors that have been received by Dr. Shannon are the Alfred Noble Prize of the American Institute of Electrical Engineers, the Morris Liebmann Award of the Institute of Radio Engineers, the Stuart Ballantine Medal of the Franklin Institute, and the Research Corporation Award.

Report of the Treasurer

■ The major trends and developments in Institute financial affairs for the fiscal year 1957–1958 are summarized below by Joseph J. Snyder, '44, Treasurer:

	1957–58	*1956–57*	*Change*
Academic operations	$20,905,000	$19,489,000	+$1,416,000
Division of Sponsored Research	54,344,000	49,118,000	+ 5,226,000
Total funds	91,773,000	87,471,000	+ 4,302,000
Plant assets	43,251,000	41,309,000	+ 1,942,000
Gifts and grants	7,732,000	8,498,000	— 766,000
Investments — market value	132,150,000	128,086,000	+ 4,064,000
Investments — book value	89,267,000	85,314,000	+ 3,953,000

Operations

The operations of the Institute in 1957-1958 are set out in the following exhibit:

Revenues and funds	*1957–58*	*1956–57*
Tuition and other income	$ 6,485,000	$ 6,458,000
Investment income	1,913,000	1,793,000
Gifts and other receipts	4,481,000	4,215,000
Contract allowances for indirect expenses	6,211,000	5,230,000
Auxiliary activities	1,815,000	1,793,000
Total	$20,905,000	$19,489,000
Expenses		
Academic	$ 8,718,000	$ 8,116,000
General and administration	7,149,000	6,272,000
Plant operations	3,210,000	3,136,000
Auxiliary activities	1,828,000	1,965,000
Total	$20,905,000	$19,489,000

The growth in academic expenses was financed in part by a special distribution of investment income and a further increase in the use of gifts and other receipts for current purposes. Contract allowances for indirect expenses on sponsored research were higher in 1957-1958, in keeping with the increase in general and administration expenses including salary and wage adjustments and employee benefits. In 1957-1958 the volume of sponsored research was 12 per cent above the preceding year.

Gifts

The gifts for 1957-1958 are compared to 1956-1957 in this table.

	1957–58	1956–57
Gifts for endowment	$1,138,000	$2,381,000
Gifts for buildings	195,000	731,000
Gifts for current use — invested	1,987,000	1,330,000
Industrial Liaison support	1,188,000	1,293,000
Other funds for current use	3,224,000	2,763,000
Total gifts	$7,732,000	$8,498,000

Endowment gifts received in 1957-1958 included $200,000 from the estates of Frank Hanchett and Hazel Hanchett Harvey for the Walter R. Hanchett ['15] Fund, $216,000 from the estate of F. Estelle Mosman, $178,000 from the estate of Philip A. Mosman, '87, $145,000 for the Archer E. Wheeler ['95] Scholarship Fund, and $100,000 from the Donner Foundation as the first receipt for an endowed professorship. Gifts directly to the Alumni Fund of $436,590 are included in gifts for current use – invested, and made up a part of the total credited by the Alumni Fund Office. Contributions for the Faculty Salary Adjustment Fund of $1,256,000 were received during 1957-1958 and served to increase the gifts for current use – invested over 1956–1957.

Funds

Endowment and other funds increased by $4,302,000 during 1957-1958:

	1957–58	1956–57
Endowment for general purposes	$36,162,000	$34,902,000
Endowment for designated purposes	20,768,000	19,882,000
Total endowment funds	$56,930,000	$54,784,000
Other funds	34,843,000	32,687,000
Total funds	$91,773,000	$87,471,000

New endowment resources were added during the year for Faculty salaries, for the academic departments, for undergraduate scholarships, and for plant operations. Increases were recorded in funds for the Faculty Salary Adjustment Fund, for new Faculty appointments, and for the funding of Faculty tenure salaries and related expenses now met with other resources.

Plant Facilities

The nuclear reactor was largely completed during the year, and construction progress at the David Flett du Pont Athletic Center brought the book value of the educational plant of the Institute to $43,251,000 on June 30, 1958, compared to $41,309,000 on June 30, 1957.

Investments

The investment position of the Institute on June 30, 1958, and June 30, 1957, is presented in the following table, which is exclusive of the investments of the M.I.T. Pension Association and the Supplementary Retirement Plan:

	June 30, 1958		June 30, 1957	
	Book Value	Market Value	Book Value	Market Value
General investments				
Bonds	$43,759,000	$ 43,869,000	$42,550,000	$ 39,957,000
Stocks	24,054,000	63,754,000	22,122,000	64,049,000
Real estate	12,087,000	12,087,000	11,863,000	11,863,000
Commercial paper	2,471,000	2,471,000	2,208,000	2,208,000
Total	$82,371,000	$122,181,000	$78,743,000	$118,077,000
Special investments	4,766,000	7,839,000	4,791,000	8,229,000
Student notes receivable	2,130,000	2,130,000	1,780,000	1,780,000
Total	$89,267,000	$132,150,000	$85,314,000	$128,086,000

Funds sharing in the income from the general investments earned 6.2 per cent on the average book value compared to 6.14 per cent last year. This year 5 per cent plus a special distribution from accumulated investment income of 1/2 of 1 per cent was allocated to the funds. The total income on the general and special investments in 1957-1958 was $4,548,000, compared to $4,263,000 in 1956-1957.

The proportion of the general investments in bonds at market value was 33.8 per cent on June 30, 1957, and 35.9 per cent on June 30, 1958. The proportion of investment income from bonds increased from 30.1 per cent to 33.9 per cent. At market values the proportion of the general investments in common stocks decreased from 53.7 per cent on June 30, 1957, to 51.3 per cent on June 30, 1958. Investment income represented by common stock dividends declined from 57.0 per cent in 1956-1957 to 54.2 per cent in 1957-1958.

The investments of the M.I.T. Pension Association and the Supplementary Retirement Fund on June 30, 1958, and June 30, 1957, are presented in the following exhibit:

	June 30, 1958		June 30, 1957	
	Book Value	Market Value	Book Value	Market Value
Pension Association	$ 8,390,000	$11,250,000	$7,260,000	$ 9,800,000
Supplementary Retirement Fund	2,667,000	2,827,000	1,545,000	1,606,000
Total	$11,057,000	$14,077,000	$8,805,000	$11,406,000

General

The increase in the funds of the Institute of $4,302,000 in 1957-1958 compares with $4,792,000 in 1956-1957, when a substantial endowment gift was received. The increase in endowment was $2,146,000 in 1957-1958 in contrast to $3,700,000 in 1956-1957.

Student loans outstanding expanded further during the year to $2,130,000 on June 30, 1958, compared to $1,780,000 on June 30, 1957, and $787,000 five years ago. As tuition has increased, the loan funds of M.I.T. have become a more important source of financing for students at the Institute.

Weber Becomes Army Consultant

■ Harold C. Weber, '18, Professor of Chemical Engineering, who came to the Institute in 1922 and who has been the recipient of many honors as a civilian and Army officer during both World Wars, has been appointed chief scientific adviser to the Army's Chief of Research and Development. The announcement of this appointment was made on October 8 by Wilber M. Brucker, Secretary of the Army, but Dr. Weber will continue to serve on the Institute's Faculty.

Professor Weber has been a member of the Army Scientific Advisory Panel for many years. He has also been chairman of the Chemical, Biological and Radiological sub-panel of the A.S.A. Panel. He is author of the textbook *Thermodynamics for Chemical Engineers* and of numerous technical papers; he also contributed the sections on thermodynamics and refrigeration to Marks's well-known *Mechanical Engineers' Handbook*.

During World War I, following his graduation from the Institute with a bachelor's degree in Chemical Engineering, Professor Weber served as a second lieutenant in the aviation section of the Signal Corps and later in the Chemical Warfare Service. In 1922 he became a Faculty member at the Institute. In 1934 he received the D.Sc. degree from the Eidgenosiche Technische Hochschule in Zurich. During World War II he was technical adviser to the Chemical Warfare Development Laboratory at M.I.T. For his important work during World War II, Dr. Weber was awarded the Presidential Certificate of Merit and the Chemical Corps' Certificate of Achievement. He has been chairman of the Advisory Committee to the Chemical Corps for the past five years.

Meeting 333

■ Business – a good deal of it – was transacted at the 333d meeting of the Alumni Council, the first of the current school year, which was held at the M.I.T. Faculty Club on Monday, October 20. As President of the Association, John J. Wilson, '29, opened the meeting of 157 members and guests.

First item of business was a report by Donald P. Severance, '38, Secretary-Treasurer, in which changes in class affiliation for four Alumni were announced as having been approved. During the summer months, nine members of the M.I.T. staff and officers of the Association had paid visits to 15 M.I.T. clubs within the area bounded by Toronto, Atlanta, Albuquerque, and Honolulu. Excess of the Association's budget over disbursements, and of income over expenses for The Review were reported. Also reported as having the approval of the Association's Executive Committee was a slate of nominees for Departmental Visiting Committees to be submitted to the M.I.T. Corporation; a number of new Class Representatives, Club Representatives, and Associates to serve on the Alumni Council were also named.

Edwin D. Ryer, '20, chairman of the Alumni Fund Board, reported on the success of the Second Alumni Fund Conference (as summarized on page 26 of the November issue of The Review), and Hugh S. Ferguson, '23, chairman of the Audit and Budget Committee, reported that the accounts of the Alumni Association and The Review had been examined and found to be in order.

James M. Driscoll, '96, and F. Leroy Foster, '25, presented resolutions, respectively, on the late John A. Rockwell, '96, and George A. Packard, '90. The resolutions were adopted by a silent rising vote.

It is customary for the Secretary in his report to the Alumni Council to summarize the M.I.T. clubs that have been visited since the last meeting by members of the Institute family. This past spring H. B. Richmond, '14, Life Member of the M.I.T. Corporation and a Past President of the M.I.T. Alumni Association, visited the M.I.T. Association of Japan on his trip to the Orient. As an indication of the value of M.I.T. clubs and what they stand for, Mr. Richmond described his visit with our Japanese Alumni; the responsibilities that these men have in their country, the interest they have in the affairs at M.I.T., and their indescribably warm hospitality.

Final speaker of the evening was William P. Allis, '23, Professor of Physics at the Institute, whose topic was "The Present State of Research on Controlled Fusion." Professor Allis was one of several members of the M.I.T. staff who were at the second United Nations Conference on the Peaceful Uses of Atomic Energy at Geneva, with a particular interest in the week of sessions on thermonuclear fusion.

This 1958 Atoms for Peace Conference was about twice the size of the 1955 Conference. There were approximately 5,000 delegates. Twenty-three hundred papers were submitted (144 on fusion) and 650 papers orally presented (45 on fusion). In 1955 the secret work on fission was declassified; in 1958 the work on fusion was declassified.

Showing colored pictures, principally of the exhibits of the U.S.S.R. and the U.S., Professor Allis described, in elementary terms, the physical principles underlying thermonuclear fusion; and he described the various devices that have been developed in Russia and in this country at Princeton, University of California Radiation Laboratory, Oak Ridge, and at Los Alamos in an attempt to contain thermonuclear reactions and avoid the various types of instability.

One commonly hears that by 1975 nearly all new power stations that will be built will be operated on nuclear energy – from controlled fission. It is still anyone's guess when controlled fusion will be available for the economic production of power. Professor Allis' estimate is that controlled fusion reactions will be commonplace in 10 years; power will be available from fusion in 30 years; and the economic production of power will take 100 years.

On the Horizon

January 31, 1959 – 14th M.I.T. Alumni Regional Conference, Detroit, Mich. (For reservations, consult Thomas F. Morrow, '35, Chrysler Corp., 341 Massachusetts Avenue, Detroit 31, Mich.)

March 12–14, 1959 – 11th Annual Fiesta, M.I.T. Club of Mexico, Mexico City, D.F. (For reservations, consult Clarence M. Cornish, '24, Margaritas 257, Villa Obregon, Mexico 20, D.F., Mexico.)

Photo by Edwin Gray, Falmouth

Members of the Class of 1913 with their wives and guests totaled 59 who celebrated the 45th reunion of the Class at the Oyster Harbors Club in Osterville. Photographed on June 14, the group enjoyed a week end on Cape Cod, just preceding Alumni Day activities on June 16 at the Institute. Reunion chairman was William R. Mattson of Newtonville.

Relatively Speaking

■ Delving into statistics on this year's Freshman Class, evidence discloses several familial ties (parents, grandparents, uncles, cousins, and brothers) existing between some of the 900 first-year students and Alumni who matriculated at M.I.T. in former years. Of this group with M.I.T. kinsmen, The Review is pleased to list below the 37 who are sons of Alumni – and in one case, a grandson of an Alumnus:

Student	*Father*
Yuan B. Chu	Lan J. Chu, '35
Harvey E. Cline	Max Cline, '05 *(Grandfather – Deceased)*
Timothy P. Coffey, Jr.	Timothy P. Coffey, '32
John L. Costello	Angelo Costello, '26
John M. D'Albora	John B. D'Albora, Jr., '34
James S. Draper	Charles S. Draper, '26
James C. Evans, Jr.	James C. Evans, '25
Edward A. Feustel	Fred P. Feustel, '33
Charles G. Glueck, Jr.	Charles G. Glueck, '34
Michael A. Gorfinkle	Meyer G. Gorfinkle, '27
Arthur L. Harper	Donald R. Harper, '40
Steven L. Kleiman	Macklen Kleiman, '35
David H. Koch	Fred C. Koch, '22
William I. Koch	Fred C. Koch, '22
Randall H. Kunz	Warren J. Kunz, '34
Vincent E. Lysaght, Jr.	Vincent E. Lysaght, '24
Robert A. Lytle, Jr.	Robert A. Lytle, '30
Donald P. Martin	Byron N. Martin, '31
Edward M. Myskowski	Leo J. Myskowski, '28
Charles W. Niessen	William Niessen, '33
Stephen E. Phinney	Robert M. Phinney, '04
David F. Pope	Harold W. Pope, '39
Frederick A. Prahl, 3d	Frederick A. Prahl, Jr., '36
Laurence R. Proulx	Louis J. Proulx, Jr., '36
Richard P. Rae	James R. Rae, '28
Stephen C. Root	Darrell A. Root, '35
James A. Ross	Charles H. Ross, '35
Bardwell C. Salmon	Chenery Salmon, '26
Philip R. Sheridan	Philip E. Sheridan, '42
Bruce E. Sherrill, Jr.	Bruce E. Sherrill, '28
Richard S. Shirley	Paul J. Shirley, Jr., '38
Douglas W. Steele	Ernest R. Steele, '32
Robert B. Strong	Robert L. Strong, '32
Stephen D. Uman	Abraham S. Uman, '30
Michael W. Waidelich	Alfred T. Waidelich, '30
Fredric C. Weihmiller	Horace E. Weihmiller, '25
George M. Wyman	George F. Wyman, '30

Educational Services

■ The formation of "Educational Services, Inc." was announced late in October by Detlev W. Bronk, President of the National Academy of Sciences, and J. A. Stratton, '23, Acting President of the Institute. The new corporation is an independent, nonprofit organization to take over from the Institute the major responsibility for continuing the work of its Physical Science Study Committee in developing new methods and materials for the teaching of secondary school physics. The National Academy of Sciences was instrumental in bringing to culmination plans for forming the new corporation.

As announced in the February, 1957, issue of The Review (page 194), the Physical Science Study Committee was established at M.I.T. in 1956 when President James R. Killian, Jr., '26, and Jerrold R. Zacharias, Professor of Physics, called together a distinguished group of scientists to seek ways in which the teaching of physics in secondary schools could best meet the challenge of the Twentieth Century. The over-all goal of the Committee was to develop and to make available new techniques for the teaching of science. The pioneering work of the Physical Science Study Committee was reported in "Educational Methods and Today's Science – Tomorrow's Promise" by Professor Zacharias in The Review for July, 1957.

Laird Bell of Chicago has been elected chairman of the Board of Trustees, and James E. Webb of Oklahoma City as president of the new organization which has headquarters at Watertown, Mass. Among the facilities available to Educational Services, Inc. is a studio in which motion pictures for classroom use are being made. The preparation of a new textbook, the development of do-it-yourself laboratory apparatus, and the writing of numerous paper-bound books to interest young people in various technical areas of scientific study are among the projects being conducted by Educational Services, Inc.

During the past two years, several hundred high school teachers in physics have been trained in the aims and methods of this new curriculum, and it is expected that this year some 12,000 students will be taught the new program.

Individuals Noteworthy

■ Prominent in the news during the fall were the 20 promotions, elections, or appointments enumerated below:

Paul W. Litchfield, '96, as Honorary Chairman, and *Russell DeYoung, '40,* as President, Goodyear Tire and Rubber Company . . . *John C. Barker, '20,* as Director, Maine Medical Center;

Arthur E. Raymond, '21, as Senior Vice-president in charge of Engineering, Douglas Aircraft Company . . . *James H. Doolittle, '24,* as Chairman-elect, Space Technology Laboratories . . . *Garvin A. Drew, '25,* as Manager, A. Schrader's Son Company, Brooklyn, N.Y.;

Donald G. Vaughan, '25, as President, the American Society of Safety Engineers . . . *Vice-Admiral Clarence E. Ekstrom, '31,* as Commander of the Sixth Fleet, United States Navy;

John Chipman, Professor of Metallurgy at M.I.T., and *John H. Hollomon, '40,* as President and as Director, respectively, of the Metallurgical Society of the American Institute of Mining, Metallurgical and Petroleum Engineers; *Oscar T. Marzke, '32,* as Chairman, Institute of Metals Division, and a Director, the Metallurgical Society, A.I.M.E.;

Stanley H. Walters, '33, as Vice-president – Sales, Calidyne Company, Inc., Winchester, Mass. . . . *George Wrigley, Jr., '33,* as President, J. E. Sirrine Company, Greenville, S.C. . . . *Edward L. Dashefsky, '36,* as Plant Manager, Missile Plant, Raytheon Manufacturing Company, Lowell, Mass.;

Irving N. Kelsey, '36, as Manager, Pittsfield restaurant, Friendly Ice Cream Company . . . *George J. Schwartz, '42,* as President, Yankee Post, American Ordnance Association . . . *Eric M. Wormser, '42,* as Vice-president in charge of Engineering and Sales, Barnes Engineering Company, Stamford, Conn.;

Lewis A. Rupp, '43, as Vice-president and General Manager, Ionics, Inc., Cambridge . . . *H. Gordon Fromm, '50,* as Vice-president, Operations, International Latex Corporation, Dover, Del. . . . *George B. Stone, '58,* as General Manager, J. B. Roerig and Company division, Charles Pfizer and Company, Inc.

■ Special honors recently announced or awarded to 10 Alumni – two of whom are members of the Institute's Faculty – are as follows:

To *Ernest B. MacNaughton, '02,* an Award for Distinguished Service to the state of Oregon, by the University of Oregon . . . to *Thomas C. Desmond, '09,* its Certificate of Merit, by the City Club of New York; and a plaque commemorating distinguished services to the engineering profession, by the New York State Society of Professional Engineers . . . to *Crawford H. Greenewalt, '22,* the 1958 Medal for the Advancement of Research, by the American Society for Metals;

To *Charles S. Draper, '26,* Professor of Aeronautical Engineering at the Institute, the Blandy Gold Medal for "distinguished services related to all phases of naval ordnance progress," by the United States Navy . . . to *James B. Fisk, '31,* an honorary doctorate of science, by Williams College . . . to *Leo B. Moore, '37,* Associate Professor of Industrial Management at M.I.T., the grade of fellow, for outstanding service to standardization, by the Standards Engineers Society;

To *John H. Kempster, '47,* the Lybrand Gold Medal for the best paper submitted from April, 1957, to April, 1958, by the National Association of Accountants . . . to *Robert T. Ryland, Jr., '51,* a Superior Accomplishment Award for outstanding work performance, by the U.S. Naval Proving Ground, Potomac River Naval Command . . . to *Alan L. McWhorter, '55,* and *James W. Meyer,* both of M.I.T. Lincoln Laboratory, an Annual Award Certificate for the best technical paper presented at last year's conference, by the National Electronics Conference.

I.L.O. Director

■ Vincent A. Fulmer, '53, has been appointed director of the Institute's Industrial Liaison Office, succeeding William R. Weems, '35, who has served as director of I.L.O. since 1952. Mr. Weems left the Institute late in October to work with the International Coöperation Administration in the development of industry in Korea.

First appointed Industrial Liaison Officer in 1953, Mr. Fulmer has been assistant director of I.L.O. since 1956. In 1949 he was graduated *cum laude* from Miami University in Oxford, Ohio. He took graduate work in industrial economics at M.I.T. and was formerly on the teaching staff in the Department of Economics and Social Science at the Institute, and later, at Williams College. He is a member of Phi Beta Kappa, as well as of the American Economic Association, the Institute of Management Sciences, and the Operations Research Society of America.

Mr. Weems was born in Kaesong, Korea, of missionary parents. He was graduated from the Georgia Institute of Technology in 1933 and received the S.M. degree from M.I.T. in 1935. After two years of engineering work on aircraft instruments he taught aeronautical engineering at Georgia Institute of Technology. During World War II he became a lieutenant colonel and was appointed assistant commandant at Wright-Patterson Air Force Base. He was named assistant professor of aeronautical engineering at M.I.T. in 1946, and became associated with the Industrial Liaison Office in 1950. In 1955-1956 he worked in Korea under the United States technical assistance program.

The Industrial Liaison Office was initiated in 1947 to correlate and strengthen the nation's industrial and academic resources. It administers a program by which industry may have a direct link with the entire range of nonclassified research in which M.I.T. is engaged. The I.L.O. actively attempts to bridge the gap between the Institute's creative efforts and industry's commercial developments resulting from newly acquired knowledge. The I.L.O. program also assures a realistic orientation and vigorous implementation of the basic educational efforts being conducted at M.I.T. as reflected by the nation's technological needs. With the help and co-operation of the Faculty, the I.L.O. is responsible for implementing the Institute's contractural arrangements with some 90 industrial firms affiliated with the Industrial Liaison Office.

Fair and Sunny

■ Historically, weather forecasting developed as a qualitative art, devoid of any fundamental basis in the laws of meteorological hydrodynamics and thermodynamics. In the past decade, vigorous research efforts have led to substantial increases in man's understanding of the evolution of atmospheric patterns of air flow, and have placed the prediction of tomorrow's pattern of air flow upon a sound theoretical basis. This achievement, however, deals with only a portion of the total problem of weather forecasting, since it leaves untouched the important problem of whether tomorrow will be sunny or rainy.

Fortunately, there is a link between the pattern of air flow and the occurrence of cloudiness and precipitation. It is clear that significant condensation of water in the atmosphere occurs as a consequence of the vertical component of air motion. That is, rising air expands and cools as it moves toward lower pressure aloft. Since the saturation vapor pressure varies directly with temperature, such cooling may produce saturation with respect to water vapor in the rising mass of air. Any further ascent is accompanied by condensation of water in the form of tiny cloud droplets, and this process leads typically to the formation of precipitation. On the other hand, descending air is warmed by compression. In this circumstance, no condensation will occur; indeed, cloud droplets already present in a sinking mass of air will tend to evaporate.

Two typical scales of vertical motion may be distinguished, as shown in Figs. 1 and 2. Large-scale motion occurs over areas of the order of hundreds of thousands of square miles, but the intensity of vertical motion (indicated by lengths of arrows) is only a few hundredths of a mile per hour. This motion is related to the systems of high and low pressure found on the weather map and to their accompanying broad regions of clear skies and extensive cloudiness and precipitation. A small-scale pattern of vertical motion is associated with individual clouds of the cumulus type. These patterns occur over areas of only a few square miles but may attain considerable intensity, of the order of tens of miles per hour.

The small-scale vertical motion may be measured directly, but so far its small extent, both in time as well as in space, has precluded attempts to predict its effects, except in a statistical sense.

At present, it is not possible to measure directly the large-scale vertical motions. The theory underlying the prediction of the patterns of horizontal air motion, however, also implicitly contains a prediction of the large-scale vertical component. Research directed toward the elucidation of this type of estimate of vertical motion and its relationship to cloudiness and precipitation has been undertaken by Frederick Sanders, '54, Assistant Professor of Meteorology. A summary of some of the results of this work for central and eastern United States during the colder half of the year is presented in Fig. 3.

It is seen that both types of weather phenomena are related to the vertical motion in the expected sense. Thus, when the air is ascending, sunny skies are relatively infrequent while precipitation occurs relatively often. This situation is reversed when the large-scale vertical motion is downward.

It is evident from the data in Fig. 3 that forecasts of sunny skies or of precipitation cannot be made solely on the basis of this estimate of vertical motion with an assurance of more than about 45 per cent. An improvement in the results has been obtained by considering the initial water-vapor content of the rising or sinking air. Further improvement will likely result from a more adequate theoretical estimate of the vertical motion, in which account is taken of: (1) the effects of the flow of air over sloping terrain; (2) friction between the earth's surface and the overlying air layer; (3) heating or cooling of the air by contact with land or water surfaces; and (4) the susceptibility of the air to small-scale vertical motions.

To date, the results do not provide an immediate prospect for substantial improvement in weather forecasts. Nevertheless, a basis in hydrodynamics and thermodynamics has been placed under the qualitative art of prediction of cloudiness and precipitation, and prospects for further progress are good.

This research is sponsored by the Geophysics Research Directorate of the Air Force Cambridge Research Center.

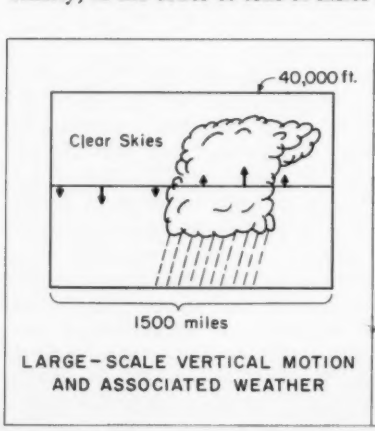


Fig. 1. Vertical motion of air and associated weather conditions over large-scale terrain.

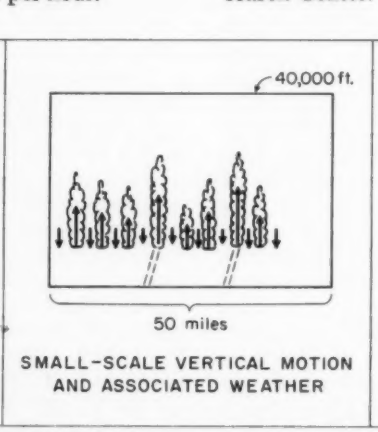


Fig. 2. Vertical motion of air and associated conditions over local area of about 50 miles.

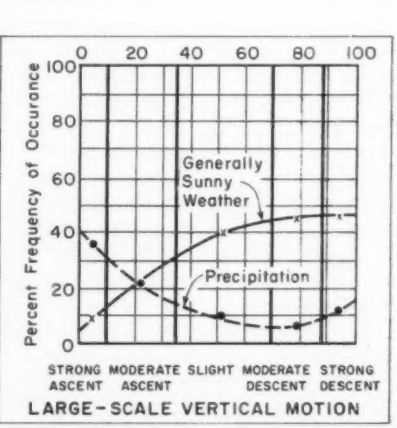


Fig. 3. Correlation between vertical motion of air and precipitation or sunny weather.

Industrial Dynamics

■ During the next 25 years we can expect changes in the management profession that are as spectacular as the changes that have already occurred in engineering over the last quarter century. Numerous "management science" research groups are exploring the principles that underlie industrial and economic behavior. As these principles are validated and reduced to usable form, they should provide a foundation for management progress as effective as the underlying principles of physics provide for engineering.

An excellent example of this is the study of "industrial dynamics" being conducted in the M.I.T. School of Industrial Management, under the direction of Jay W. Forrester, '45, Professor of Industrial Management, and supported by the Sloan Research Fund, the Ford Foundation, and industrial companies.

In this program, which has been under way for more than a year, a company is analyzed, taking account of the effects of time delays, information sources, organizational forms, and management policies. These factors can then be shown to interact in a way that may create the employment, inventory, and production fluctuations that are so often attributed solely to external causes. The analysis must incorporate the basic characteristics of the company like factory lead time, inventory policies, construction time for new plants, union contract provisions, and advertising policies. Such items are the ones the manager considers and tries to interrelate in the everyday intuitive management of a business. In a more complete representation of the company, intangible items must also be specified, such as, the likelihood of results from research expenditures, consumer response to advertising, and market behavior. At first, the analysis can use estimates of these factors and later the analysis itself can indicate which factors justify more careful measurement. Eventually this quantitative understanding of many of the underlying organizational and economic principles should make possible the "design" of organizational forms and policies that enhance the management objectives.

More companies fail from poor management than from poor engineering. Yet, we have the anomaly of thorough systems studies on products and almost none on the behavior and future prospects of the company itself. Research on devices is fashionable. Research toward better management has yet to be fully appreciated.

The industrial dynamics program at M.I.T. is aimed at four goals:

1. To develop in the manager a better intuitive feel for the time-varying behavior of industrial and economic systems. Quantitative studies are beneficial even before one has accurate data. They explain the nature and interaction of the forces that control the company. They show critical areas and highlight points that need careful attention.

2. To provide a background showing how the major aspects of a company are related to each other, so that the developing manager can derive the greatest benefit from his work experience. His operating experience should be more meaningful if he has a better understanding of how his immediate environment is related to the fluid, changing character of the company as a whole.

Photo by Bill Sears from Black Star

As the world's industry continues to expand, better understanding of the forces causing industrial fluctuation, growth, and stability is required; it is being achieved through modern techniques of analysis in which large-scale computers are bound to play an increasingly significant role.

3. To help predict the future course of an existing organization. Present decisions often determine the future company welfare five years or more into the future. Underlying, unchanging characteristics of a company can cause erratic manifestations in operations. We can hope, eventually, for better ability to see where present company practices are to lead.

4. To improve the future prospects of a company. Beyond prediction, lies the ability to redesign an organization and its policies to improve its chances of success.

Industrial dynamics is in an early stage of development. Although even preliminary studies can have immediate value in guiding intuitive decisons, the full impact will not be felt for one or two decades.

It now appears that the next five years will be devoted to exploratory research, development of basic analytical techniques, demonstrating practical importance through success in specific industrial situations, and establishing new academic programs for training future managers.

Already there has been substantial progress. Industrial dynamics is being taught in the program of the Sloan Fellows and as a graduate subject in the M.I.T. School of Industrial Management. Last summer, during the last two weeks of August, a special summer program for men from industry was offered for the first time. A growing number of graduate theses are exploring the basic principles that underlie major management problems — the causes of economic fluctuation, the management of research in new technological developments, and instability of the textile industry.

From initial research that started with the core of production and distribution activities, the studies are gradually being extended into pricing, advertis-

ing, market behavior and capital equipment. A group is starting under John L. Enos, '49, Assistant Professor of Industrial Management, to evolve a much more comprehensive mathematical model of national economic phenomena than has ever before been undertaken. This will use information flow and decision making as the framework to tie together sectors representing agriculture, non-durables, consumer durables, capital equipment, secondary manufacturing, extractive industries, financial institutions, credit, labor supply, and the consumer market.

Twenty-five Years Ago This Month . . .

■ Technology's annual fiscal report by Treasurer Everett Morss, '85, covering 1932-1933, showed that the Institute's net operating income had declined to $2,780,000, or 8 per cent under that of 1931-1932; but net operating expense also had been reduced so that the deficit for 1932-1933 was $5,727 compared with $15,575 in the previous fiscal year.

Mr. Morss reported that on the previous June 30 the book value of the Institute's "land, buildings, and equipment" and its "endowment funds" were recorded, respectively, as $15,703,259 and $32,731,230. Capital gifts, however, totaled but $175,000 for 1932-1933, the lowest of any fiscal year since 1911.

Everett Morss, '85

Income from students was $1,425,000, which was $114,000, or 7 per cent less than in 1931-1932 — thus reflecting a corresponding drop of 11 per cent in enrollment. Of the $1,425,000 of income from students, $335,950, or 23 per cent, was provided by scholarships and loans — a much higher proportion than in any previous year.

■ Registrar Joseph C. MacKinnon, '13, according to his annual census of the student body made November 1, found that the 1933-1934 registration totaled 2,606, a drop of 225, or 8 per cent, from 1932-1933.* The entering Freshman Class of 1937 numbered 485, or 77 less than the entering Freshman Class of 1936. Sophomores were 39 less than in 1932-1933, juniors were 93 less, and graduate students 27 less; but there were 11 more seniors than in the previous year.

■ The American Association for the Advancement of Science, then comprising 139 national scientific and engineering organizations with a total membership of 20,000, held its 93d session in Cambridge and Boston. *Samuel C. Prescott, '94,* the Institute's Dean of Science, was chairman of the local committee in charge of arrangements, and *Professor Arthur L. Townsend, '13,* of the Department of Mechanical Engineering, was the committee's secretary.

■ Congratulations were being extended to *Christopher J. Carven, '84,* upon becoming Commissioner of Public Works for the City of Boston; . . . to *Albert Sauveur, 89,* as a new honorary member of the American Institute of Mining and Metallurgical Engineers; . . . to *Robert T. Haslam, '11,* and *Rufus E. Zimmerman, '11,* recently appointed Vice-presidents, respectively, of the Standard Oil Development Company and the United States Steel Corporation; . . . and to *Professor Arthur C. Hardy, '18,* upon his election as Vice-president of the Optical Society of America.

*The Institute's registration curve following World War I rose to a high of 3,505 in 1921-1925, then dropped to a low of 2,671 in 1926-1927, rising to its next high of 3,209 in 1930-1931. From that year on, it declined to a low of 2,507 in 1934-1935 before turning upward to reach its next high of 3,138 in 1940-1941.

Athletic Résumé, 1957–1958

Supplementing the various athletic reports printed in the November issue (page 25), The Review is pleased to present, in the following paragraphs, additional reports on four athletic teams as prepared by: Coach Frank S. DuBois, Jr., on the heavyweight crew; Coach Charles Batterman on freshman lacrosse; Coach Edward A. Crocker on varsity tennis; Assistant Coach Arthur E. Farnham on Track and Field.

Crew

The 39th season for M.I.T.'s varsity heavyweight crews has not been a particularly auspicious one in the win-loss column, but it has been an encouragingly competitive one in many ways. In an over-all total of 18 races, the heavyweight upperclassmen have met 48 shells in intercollegiate competition. They were bettered by 31 of these and won over 17 of them. Although this leaves much room for desired improvement, it was hearteningly supported throughout by the desire and inclination of the oarsmen themselves.

This was a season which saw increased participation in the form of three varsity crews on the water until finals, and one which saw an M.I.T. junior varsity crew at the Intercollegiate Rowing Association Regatta for the first time since 1949.

At the I.R.A. Regatta at Syracuse in June, generally accepted as the best test of any given crew's composure and ability after a season's work and conditioning, the varsity crew surprised everyone by leading the field of 10 varsity crews for the first mile and a half of the three-mile encounter. They were a strong crew individually, but lacked the conditioning, for the most part, of their rivals for this distance. Their unusually late spring start, due to weather and minus indoor facilities, and their later-than-usual finish in June, due to the school calendar, were definite handicaps.

But nonetheless, they were a squad that rowed hard and faithfully. As a final varsity and junior varsity, they earned respect; were competitive with their rivals within the limits of their ability; and

(Continued on page 110)

A Co-operative Training Program for Exploration Geophysicists

Industry-wide support is accorded a program, initiated in 1951, which permits students of geophysics to learn while they earn

by ROBERT R. SHROCK

LAST summer 18 undergraduate students, representing 18 U.S. schools (including M.I.T.) and carefully selected from more than 600 applicants, spent three months as helpers on seismic and gravity field parties. They were employed by a Texas-based geophysical company and were participants in a unique co-operative training program originated by an M.I.T. Alumnus and an M.I.T. professor. These carefully chosen fourth- and fifth-year students, mainly geologists and geophysicists but including a pre-law student and several liberal arts majors, participated in a co-operative educational effort sponsored by Geophysical Service Inc. of Dallas, Texas. The former president and present chairman of the board of Geophysical Service Inc. is Cecil H. Green, '23, himself the product of a co-operative plan still going full force in the Institute's Department of Electrical Engineering.

The G.S.I. Student Co-operative Plan, as this educational project is now designated, was initiated in the summer of 1951. During its eight summers of operation it has given valuable training to 161 student participants, almost all of whom have either accepted employment in the petroleum industry or are continuing graduate work with this ultimate objective.

The co-operative plan in geophysics was born one spring afternoon in 1951 when Dr. Green paid a visit to the Institute. During this visit, Dr. Green called at the headquarters of the Department of Geology and Geophysics to learn whether some students in geophysics in Course XII might be interested in summer employment with his firm, Geophysical Service Inc. This firm contracts its seismic and gravitational exploration services, on a world-wide basis, to the petroleum industry and would be in an excellent position to attract students for summer work.

The very enjoyable conversation the writer had with Dr. Green soon disclosed that both of us had many professional interests in common. Upon completion of their academic programs, Dr. Green also wished to employ a number of outstanding graduates in geophysics for his company. The Department of Geology and Geophysics, on the other hand, was interested in finding additional rewarding professional opportunities for some of the best students in geophysics which this Department was training. Both sides recognized the benefits to be derived by providing properly planned practical experience in the summer for students who were still engaged in academic studies during the rest of the year. Out of that afternoon conversation the broad outlines of the co-operative training program for exploration geophysicists was evolved.

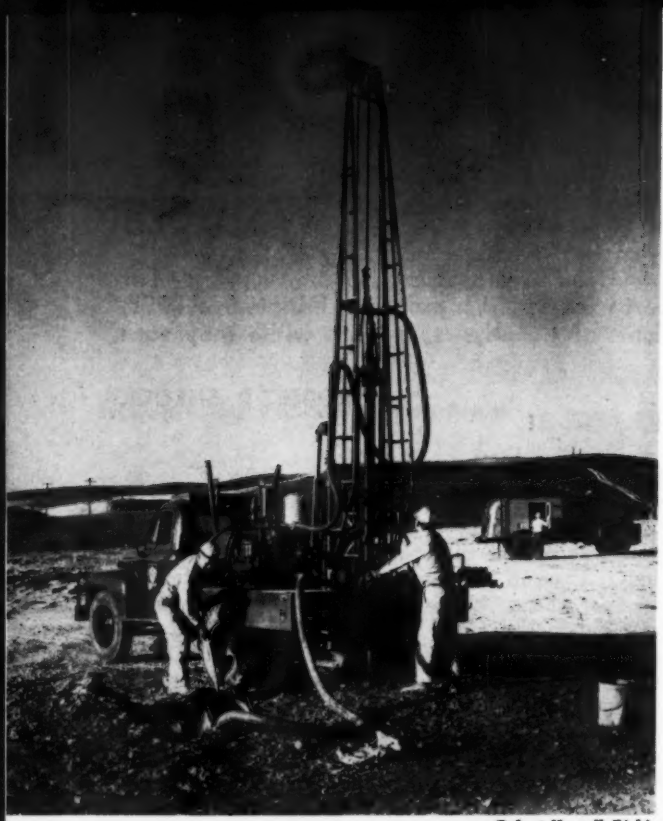
It was agreed that G.S.I. would hire the entire Junior Class of 16 Course XII geophysicists for the summer and would assign them to seismic parties working in the United States. Because M.I.T. students constituted 16 of the 19 participants that first summer, the program was called the M.I.T.-G.S.I. Student Co-operative Plan. The plan was an immediate success. By the end of the second summer, many schools were asking: "Why does M.I.T. get preferential treatment?" and "How about taking some of *our* best students?" As a consequence of these demands, the number of M.I.T. applicants was voluntarily reduced to three or four. A dozen other schools were invited to recommend one of their best students, the M.I.T. designation was dropped from the name of the co-operative plan, and the modified program emerged with its present designation – The G.S.I. Student Co-operative Plan. The extent to which the student body has changed throughout the eight years that the plan has been in operation, as more educational institutions have taken part in this unusual training program, is shown in Table I.

TABLE I

Distribution of Participants in G.S.I. Co-operative Program

Summer	M.I.T. Students	Non-M.I.T. Students	Total Number Participants	Schools Represented
1951	16	3	19	4
1952	8	13	21	5
1953	5	21	26	15
1954	4	17	21	16
1955	4	17	21	16
1956	3	17	20	16
1957	1	14	15	16
1958	1	17	18	18
	—	—	—	—
	42	119	161	44 different institutions

Since the inception of the plan, 161 students have participated. Of these, 42 have come from M.I.T. and the other 119 have represented 43 other colleges and universities. They have come from institutes of technology including M.I.T., Caltech, and Georgia Tech; from large, privately endowed universities such as Harvard, Yale, New York University, Amherst, and Williams; from smaller colleges including Franklin and Marshall, Centenary, Berea, Baylor, Marietta, and Houston; from state universities such as U.C.L.A.,



Robert Yarnell Richie

Students help regular drillers put down shallow post holes at the bottom of which an explosive charge is placed.

Texas, Oklahoma, Missouri, Kansas, Wisconsin, Iowa, and Massachusetts; and from 22 other well-known and widely scattered schools. Truly the G.S.I. Student Co-operative Plan has achieved a nationwide representation during its eight years of operation.

Because of the unusual educational opportunities offered by this plan, the very large increase in the number of applications has considerably exceeded training facilities such as even G.S.I. could provide. Therefore, during the past two summers, G.S.I. has found it necessary to limit each school to a single participant in order to treat all schools alike.

Thus, while M.I.T. is no longer able to send more than one student to the plan per summer, the Institute's Department of Geology and Geophysics can feel that it has made an important contribution to the training of future geophysicists. It has done so by helping to start, and then to support strongly, yet another pioneer effort in co-operative education in the true M.I.T. tradition of "learning by doing."

What is the Co-op Plan?

The G.S.I. Student Co-operative Plan is a program of lectures, tours, informal conferences, and field work. It is designed to give interested and qualified college students an opportunity to learn firsthand more about applied geophysics than can be taught in the classroom. It does this by providing summer employment with geophysical exploration field parties doing contract work in domestic areas for any one of the major U.S. petroleum companies.

This is how the program works. Each summer about 18 or 20 students are chosen to participate. These participants, carefully selected from a large number of applicants (more than 600 the past summer), are generally students in geophysics, geology, or engineering (less commonly in mathematics, physics, and liberal arts) who have completed at least their junior year. However, a few men with bachelor's degrees and more advanced graduate students have also been accepted in special cases. Each student selected must have a faculty recommendation, at least a "B" average, a healthy constitution, and a genuine interest in geophysics or geology as a career. All participants are paid the going salary for employees with their experience. But participation is not just a paid job on a seismic or gravity crew. It is a superb opportunity to see and take an active part in every phase of exploration geophysics and, by such practical exposure, to learn how geophysics is utilized in the constant search for geologic situations favorable for the accumulation of new oil and gas. Consequently, when assigned his duties by the particular chief of party, each co-op student knows with certainty that he is involved in an actual exploration program.

How Does the Plan Work?

The primary aims of the plan are best stated by Dr. Green as follows:

"Our foremost aim is to generate increased awareness of applied geophysics as a profession among university students and faculties. We also strive to promote closer co-operation between our industry and the academic world and to give the student a sense of direction by allowing him to experience representative conditions under which he will work if he chooses to enter the field of geophysical exploration."

With these aims firmly in mind, G.S.I. invites the student participants (together with six or eight faculty representatives from the colleges where some of the students are registered) to come to Dallas for a four-day orientation program before going to the field. Key staff members from the operating groups and research laboratories of several oil companies are also invited to participate as lecturers or conference leaders. Because the plan was initiated through the co-operation of the Institute and G.S.I. in the early years of its operation, most of the students came from M.I.T. and the orientation program was administered primarily by personnel of G.S.I. and its related Texas Instruments, Inc. As the program expanded to its second stage, students from many other colleges shared in this unusual advantage. At the same time, an increasing number of local oil companies joined in the orientation project, although the program was still generally regarded as a G.S.I. activity. With the recently held eighth session, however, the program has moved into its third phase and has taken on an industry-wide character, as numerous leading oil companies, as far away as San Francisco, sent some of their best administrators and technical personnel to Dallas to contribute to this wise and provident undertaking. Last June, 10 professors joined the students and industrial representa-

tives, so that more than 75 students, scientists, educators, engineers, and administrators united forces during the orientation activities.

Last summer's orientation program, the best yet but typical of earlier ones, presented 43 comprehensive lectures averaging nearly half an hour each, three demonstrations, guided tours of three plants and research laboratories, and motion picture films of three field operations. All were designed to outline the diversified and challenging nature of the search for oil by geophysical exploration. The list of titles of the lectures offered during the summer of 1958, given in Table II, will indicate the breadth and diversity of the orientation program.

TABLE II

Lecture Titles for 1958 Season

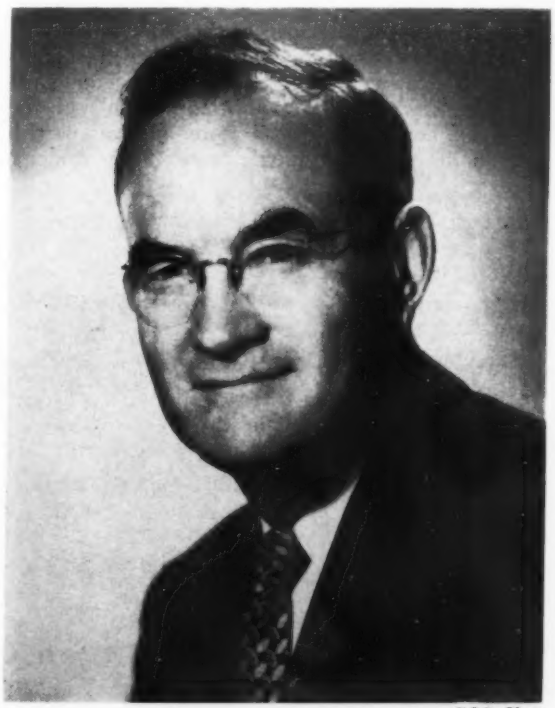
1. The Fundamentals of Petroleum Exploration (seven G.S.I. staff members)
2. Exploration Abroad from the Point of View of an Oil Company (five staff members of the Atlantic Refining Company)
3. The Processing of Seismic Data (seven staff members of G.S.I. and Texas Instruments Inc.)
4. Organization and Research within an Integrated Oil Company (11 staff members of the Magnolia Petroleum Company)
5. Petroleum Engineering and Reservoir Evaluation (DeGolyer and MacNaughton)
6. Philosophy of Seismic Interpretation (Humble Oil and Refining)
7. Electronic Surveying Methods (Shell Development Company)
8. What is a Gravity Anomaly? (G.S.I.)
9. The Significance of Gravity Fields (Shell Oil Company)
10. The Use of Geophysics in Discovery and Development (Texaco-Seaboard Oil Company)
11. Topographic and Near Surface Effects on Seismic Data (Texaco-Seaboard Oil Company)
12. Using the Tools of Our Profession (Tennessee Gas Transmission)
13. Progressive Integration of Seismic and Geologic Information (M. K. Brachman Company)
14. Future Needs of Geophysics (Texaco-Seaboard Oil Company)
15. The Service Company in Foreign Operations (G.S.I.)
16. Management Development at Texas Instruments (Texas Instruments Inc.)
17. What Comprises an Exploration Pattern and What Part Does the Seismograph Play in it? (California Exploration Company)
18. Summary (G.S.I.)
    (1) G.S.I.'s Safety Program
    (2) "Make No Mistake" — a sound color motion picture film showing how to work correctly
    (3) Suggestions for the summer ahead

What Do the Co-operative Students Do?

Upon arriving on the job, the co-operative student takes his assigned place on the field party and starts to work in a position as helper or assistant. During the summer the party chief rotates him from one assignment to another. In this way he gets experience in each of the following activities: surveying, drilling, shooting, recording, and office work (interpreting seismograms, and so forth). Every two weeks the party chief, in discussion with the student, prepares a personal appraisal report and submits it to G.S.I. headquarters in Dallas. A final evaluation of the student's performance is also submitted at the end of the summer. On the final day of his assignment, the student, on his part, is required to submit to G.S.I. a written report on one or more subjects in which he

F. L. Thompson

This group is learning how magnetic tape recordings are used in a modern geophysical research laboratory to analyze the traces made in the field by the shot.



G.S.I. Photo

Cecil H. Green, '23, who with Robert R. Shrock initiated the co-operative course for geophysicists.

Sounds produced by subterranean explosions are picked up by a group of pickup devices, or geophones, after being reflected by discontinuities or inhomogeneities in the earth's crust. If the geophone recordings of the blast are to have value in geophysical exploration, the positions of the geophones must be precisely known with respect to the shot point. Here co-operative students aid surveyors in determining the location of blast holes and geophones.

Robert Yarnell Richie

developed an interest during the summer. He is also encouraged to comment on G.S.I. policy, operational procedures, personnel practices, instrument design and performance, and similar matters if he cares to do so.

During the fall months, staff members of G.S.I. at Dallas carefully read and grade the written reports, correlate the merit ratings and final evaluation from the party chiefs, and ultimately draw up a tabular final evaluation report such as that shown in Table III. This report is sent to: (1) the heads of the appropriate department in each university delegating a co-operative student; (2) appropriate officials of the petroleum companies whose representatives participated in the orientation program; and (3) the students themselves. Thus every person and organization directly concerned in any way with the plan has the same information concerning student participants. Such information is useful to each department head since it enables him to compare the performance of his students, as evaluated by others, with comparable evaluations on students from other colleges. It is also useful to oil companies since it provides all of them with the same opportunity to consider students for future employment.

Although the program is arranged and financed by G.S.I., who also pays the students for their summer work, neither this firm nor the students make any commitment during the time the program is in effect regarding future employment. It is worthy of note,

G.S.I. Photo

Drilling casing being racked by Edward A. Flinn, '53, during his assignment as a co-operative student in the Texas Gulf Coast. Members of the exploration party live in the houseboat shown anchored on the far side of the sand bar.

TABLE III

7th Annual G.S.I. Student Cooperative Program
June to September, 1957
Final Evaluation Report

Degree and Major	Grad. Work Planned	Field Jobs Filled	Subject of Report	Written Quality	Report Mark	Interest in Seismic Work: Based on Written Report	Interest in Seismic Work: Based on Performance	Location of Party	Final Eval. by PC
B.S. Geology			Withdrew					La.	
B.S. E.E.	Undecided	D, S, O, R, Sh	70008 Amplifier System	Fair	12	No Comment	Average	Okla.	Above Average
B.S. Math.	Undecided	R, O, S	Weathering and Sub-Weathering in S. Central Miss.	Very Good	2	Moderate	Average	Miss.	Above Average
B.S. Math.	None	S, R, O	Effect of Hole Depth and Shooting Medium on Record Quality	Fair	13	Moderate	Outstanding	Texas and La.	Above Average
B.S. Geop.	Masters Geop.	O, R, S	Need for Versatility in a Seismic Crew	Very Good	3	No Comment	Average	La.	Average
B.S. E.E.	Undecided	S, O, R, D	Seismic Operation in a Swamp Area	Good	10	No Comment	Outstanding	La.	Outstanding
B.S. Geop.	Ph.D. Geop.	D, R, O	Experimenting for Improved Record Quality in Delaware Basin	Good	4	High	Above Average	Texas	Above Average
B.S. Geology	None	R, S, O	Working Conditions in Rapids, Avoyelles and Evangeline Parishes, La.	Very Good	1	High	Average	La.	Average
B.S. Geop.	None	O, S, R, D.Sh	General Exploration Problems in Sheffield Channel	Good	11	High	Average	Texas	Average
B.S. Geology	None	D, S, R, O	Mud Flat Operations in Laguna Madre	Good	6	Undecided	Above Average	Texas	Above Average
B.S. Geology	Masters Geology	S, O, C	Some Approaches in Detailing Salt Domes	Good	7	High	Above Average	La.	Average
B.S. Geology	M.S. Geology	S, R, Sh O	Paleozic Stratigraphy of Four Corners Area	Good	5	High	Above Average	N. Mex. and Calif.	Above Average
B.S. Geology	Masters Geology	O, S, R, D	Seismic Velocities in S. Central Miss.	Fair	14	Moderate	Average	Miss.	Average
B.S. Geology	Masters Geology	O, Sh, R, S, D	Drilling	Good	9	Undecided	Above Average	Wyo.	Above Average
B.S. Geology	Masters Geology	R, S, D, O	Miss. River Delta	Good	8	High	Outstanding	Miss.	Outstanding

O — Office; R — Recording Unit; Sh — Shooting Unit; D — Drill; S — Surveying Unit

however, that Geophysical Service Inc. has employed 25 of the 38 geophysicists (and seven of the 42 M.I.T. students) who have participated in this program and have subsequently found employment in the petroleum industry.

The Future for Co-operative Students

Probably no better evaluation of the merit of the summer co-operative program for students in geophysics can be provided than the record of their subsequent professional work. No record is presented for the 18 students who took part in the program for the summer of 1958, since they are still completing their undergraduate studies. But between 1951 and 1957, inclusive, the program had 143 student participants. Of these, more than one quarter are continuing their studies, somewhat less than half are employed in the petroleum industry, and nearly all the rest are engaged in activities related to geophysics or in which a knowledge of geophysics is essential. What ultimately happened to the 143 participants who completed their undergraduate work is shown in Table IV.

Future of the Plan

This co-operative program for exploration geophysicists is a costly one, not only in dollars but perhaps even more in the time and effort on the part of many busy persons with heavy professional responsibilities, who help put it into successful operation. One may well ask, therefore: "Is the program worth while, and should it be continued?" Here some pertinent comments are in order.

A student who participated in the program a few years ago wrote: "Until I spent a summer with a G.S.I. field party I never really knew the meaning of applied geophysics." Another commented to the head of his department at the university: "As a result of coming into direct contact with problems in our

TABLE IV

Professional Activities of Participants

During 1951–1957, inclusive, but excluding the 18 students in 1958, a total of 143 students took part in the program. They are engaged in the activities listed below:

Still in school		38	26.6%
In petroleum industry			
	Geophysicists	38	
	Geologists	23	
	Other	3	
	Total	64	44.7
Research		9	6.3
Teaching		8	5.6
Military		3	2.1
Mining		3	2.1
International Geophysical Year		1	0.7
Engineering		3	2.1
Government agencies		3	2.1
Other business		4	2.8
Unknown		7	4.9
Total		143	100.0%

seismic work, I now understand why you have advised me to take as much mathematics, physics, and electrical engineering as I can get."

The professors who have attended the orientation programs invariably come away with favorable impressions; they are enthusiastic in their support for continuing the program, and would very much like to see it expanded if possible.

But what of G.S.I., who pays the bill? Board Chairman Green says, "I feel that we are making a real contribution to the training of future explorationists for the petroleum industry and that our past efforts have definitely been worth while." President Fred J. Agnich says that, from the company's point of view, "Our Co-op Plan is a sound investment and is worthy of the fine support that all co-operating companies have given G.S.I. year after year. Even if we didn't eventually hire any of the participants, we feel that the plan is very much worth while because of the intangible benefits to us and our clients."

On the basis of many conversations I have had with Cecil H. Green, '23 – loyal Alumnus who, incidentally, now also serves Technology as a Special Term Member of the M.I.T. Corporation – I can say that the originators of the co-operative program for geophysicists are very much pleased with the training program that was devised one spring afternoon eight years ago. There is every reason, too, to be proud of the many "alumni" of this comparatively new educational enterprise, for many of them now hold important posts and are doing valuable work in the petroleum industry.

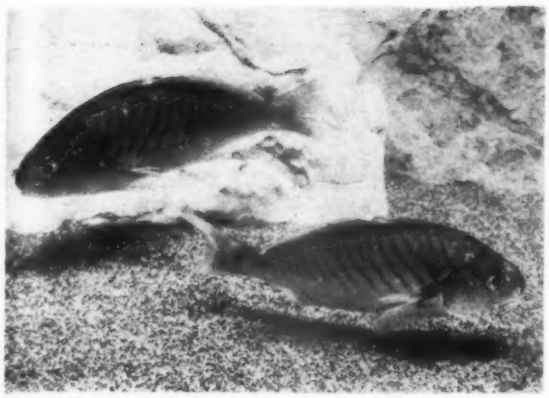
Like so many other pioneering ventures introduced by M.I.T., this student co-operative plan admirably filled a real educational need and, for this reason, won immediate acceptance and support. The intrinsic merit of the program has caused it to pass from an experiment on the part of one educational institution and one industrial firm, to a well-established and much-sought-for program. It draws exceptionally well-qualified students from across the nation, and benefits from industry-wide participation in the orientation lectures.

Of course, the natural growth of the program has diminished the number of M.I.T. students who may expect to participate in it in any given year. However, by sharing the benefits of a co-operative program in exploration geology with others, much greater benefits will undoubtedly be achieved than could possibly result from limiting the plan to its original mode of operation.

It is hoped that this significant co-operative effort on behalf of both industry and education can be expanded so that the cream of the nation's annual crop of burgeoning geophysicists will be able to enhance their education through "learning by doing."

G.S.I. Photo

A co-operative student is shown in the office, helping to analyze the seismograms recorded in the field.



John G. Shedd Aquarium

Life Is Colorful

Without its myriad colors, life would not be merely dull — it would be impossible

by FREDERIC W. NORDSIEK

NOWHERE else do beauty and utility so closely intermingle as in the colors of the living world. The greens and certain other sightly pigments of plants are the sole means whereby the plants capture energy from the sun; and only thus is any sort of life on the planet Earth made possible. The red blood pigment that brings a flush to maidenly cheeks is the oxygen-transporting principle that keeps animals alive. Other colorful biological pigments enter vitally into nutrition, vision, reproduction, and protective coloration.

Green, red, and blue are the primary colors of the physicist, and the biologist might well consider the first two of these his primary colors. The green of chlorophyll is ubiquitous throughout the plant kingdom; in trees, grasses, flowering plants, ferns, mosses, and algae; and in the seaweeds and phytoplankton of the oceans. The red of blood is undebatably the primary color of the animal world. Curiously enough, hemoglobin, the red pigment of mammalian blood, and the universal green chlorophyll of the plant world, are closely related chemically. Hemoglobin and chlorophyll contain the same chemical elements (except that iron in the former replaces magnesium in the latter), and these elements are connected in analogous molecular arrangements. The late, great biochemist Gortner epitomized the relationship thus: "If one compares the formula of hemoglobin with that of chlorophyll, it will be noted that there is a striking similarity, indicating that the most important pigment of the plant kingdom and the most important pigment of the higher animals have much in common, and are actually modifications of the same structure."

Under the Greenwood Tree

Without the green of plants, the red-blooded animals of this earth could not exist, for in the ultimate analysis virtually all forms of life draw their sustenance from green plants. These chlorophyll-bearing plants, by the process of photosynthesis, use the energy of sunlight to make complex energy-rich carbohydrates from the simple compounds carbon dioxide and water, releasing free oxygen in the process. Thus — and only thus — is captured in available chemical form the energy that sustains nearly all forms of life, whether simple or complex, animal or vegetable. Fungi, bacteria, and other forms draw their nourishment from the tissues of higher plants or animals; herbivorous animals eat plants; carnivorous animals eat other animals, whether herbivorous or omnivorous. Thus, ultimately, the sustenance of all living forms may be traced back to green plants. To provide this sustenance the plants of the entire earth take up some 7×10^{11} tons of carbon dioxide from the air each year, and produce about 5×10^{11} tons of solid plant material.

Until the advent of atomic fission and fusion, energy from the sun captured by green plants provided not only the world's supply of food energy, but also its total supply of fuel. Wood makes available for burning, energy captured by present-day green plants; peat, coal, and petroleum are mineralized re-

H. Armstrong Roberts

Shrimp diet, from which flamingos obtain carotenoids, gives these birds their pink coloring.

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All of the vertebrates – the fishes, amphibians, reptiles (such as the Gila monster shown here), and mammals ––have blood containing the red pigment hemoglobin.

mains of green plants that grew and died on earth aeons ago, far back in geological time.

Thus photosynthesis by green plants is a uniquely essential biochemical process; it is also an extraordinarily efficient process. The first investigators to undertake the formidable task of quantifying the energy interchanges in photosynthesis concluded that four quanta of red light are absorbed in the conversion of one molecule of oxygen. Later studies suggested that more, some eight or 10 quanta, are needed. Even this higher figure would mean an energy conversion efficiency of about 35 per cent. And bear in mind that no chemical reaction outside of the plant cell is known that can convert as much as 10 per cent of absorbed light into chemical energy. If such a reaction could be found with efficiency approaching that of photosynthesis, there would be less pressing need nowadays to develop atomic power.

It is now known that chlorophyll does not get all the credit for the miracle of photosynthesis; that certain yellow and orange pigments, called the carotenoids, and always associated with chlorophyll in green plants, can also absorb light energy for use in photosynthesis. Also there are bacteria, containing a purple pigment, that are capable of effecting photosynthesis provided a reducing agent is present to accept the oxygen liberated; in the absence of a reducing agent photosynthesis by these organisms stops. Green plants, in contrast, are able to discharge their oxygen in free gaseous form; indeed thus they constantly replenish the free oxygen needed for respiration by most forms of life. It has been postulated that the purple photosynthetic bacteria may be survivors of an early stage in the physiological evolution of photosynthesis.

Finally, there is evidence that a red pigment found in some algae may be an even more efficient photosynthetic agent than chlorophyll. If confirmed, this would be a significant finding, because perhaps only a tenth of the earth's photosynthesis is carried out by green plants living on dry land; the rest is probably a function of many-hued lower plants dwelling in the oceans.

The Carotenoids

The carotenoids are a group of biological pigments that merit more than passing mention. Their prototype is carotene, named after the carrot. Carotene gives carrots their distinctive orange hue, and also endows yellow corn, egg yolk, and goldfish with their characteristic colors. But the carotenoids are protean in hue. They account as well for the red of tomatoes and robin feathers, the green of avocados and lobsters, the pink of shrimps and flamingos, and a vivid blue in the sex glands of barnacles. The carotenoids serve a valuable aesthetic function – along with another important group of red, blue, purple, and lavender plant pigments called xanthophylls – as the source of color not only in flowers and decorative plants but also in the brilliant autumn foliage that is such a glorious feature of every fall season in the northeastern United States.

Carotene provides another interesting demonstration of the inseverable interdependency of animals and plants, the two broad divisions of the living world. Carotene is the precursor of vitamin A. When plant foods such as carrots or yellow corn are eaten by animals, some of their carotene is converted by the animals into vitamin A. Vitamin A is required for good nutrition by the human being and, so far as is known, by all other mammals as well. This vitamin, as such, can be made only by the animal organism; yet animals are able to make vitamin A only if they are provided with carotene as a raw material. In biochemical terminology, vitamin A is the only vitamin of exclusively animal origin that is made from a precursor of solely vegetable origin.

In the eyes of animals, vitamin A goes through further colorful vicissitudes. In the retina of animal eyes, localized in tiny organs called "rods," is a pigment known as visual purple. Visual purple is made by the body from vitamin A. Light entering the eye and striking the rods converts visual purple to visual yellow; this change instantaneously transmits a sensation of light to the nervous system. Rod vision is particularly effective in dim light. If an animal has an insufficient dietary intake of carotene or of vitamin A, there is a deficiency of visual purple and rod vision is impaired. Then a condition called "night blindness" results: for the ability to see in dim light, animals are dependent upon the plant pigment carotene.

Recently, it has become increasingly clear that the close association in plants of the carotenoids and chlorophyll is not coincidental. Pursuing lines of investigation sparked by striking similarities between the chemical structural formula of carotene and that of chlorophyll, plant biochemists have collected an impressive body of evidence suggesting that carotene is an ingredient in the natural synthesis of chlorophyll; specifically that one carotene molecule provides two of the straight chain (phytol) sections found in each cholophyll molecule.

Blood is Thicker Than Water

All of the vertebrates – the fishes, amphibians, reptiles, birds, and mammals – have blood containing the red pigment hemoglobin. Indeed these complex forms of life could not exist without hemoglobin or some equivalent oxygen-bearing principle; for only

H. Armstrong Roberts

The yellow component of the frog's green skin, the red feathers of the robin, the yellow feathers of the canary, and the yellow of many bird beaks are produced by the carotenoids.

thus can sufficient oxygen be distributed to the tissues of the higher animals. The alternative would be the distribution of oxygen in simple aqueous solution in circulating body fluids; but a watery solution of oxygen can contain, at the most, only a fortieth of the amount of oxygen that blood can contain. Hemoglobin in the circulating blood takes up oxygen by direct chemical union. In the deoxygenated form, this pigment is purplish. This form of hemoglobin combines with oxygen to become the bright scarlet oxyhemoglobin. That is why, as every knowledgeable first-aider knows, venous blood is purplish whereas oxygen-rich arterial blood is bright red.

Besides the vertebrates, many lower animals have hemoglobin in their blood. But the octopus, the snail, lobsters, and crabs are aristocrats; they are blue bloods. Their blood is blue because its oxygen-bearing principle is a blue pigment called hemocyanin. The metallic element in hemocyanin is copper, instead of the iron of hemoglobin.

A small group of marine worms possess a blood pigment known as chlorocruorin, that has the fascinating property called "dichroism"; it is both red and green. In thick layers or in concentrated solution, chlorocruorin is red; it is green in thin layers or in dilute solution. Hence the blood vessels of these creatures, viewed under the microscope, appear either green or red according to their diameter. Finally, there is a rare pink, iron-containing respiratory pigment called hemerythrin, found in a few marine invertebrates. This completes the catalogue of oxygen-carrying biological pigments; and no colorless substances having this biochemical property are known.

Many of the smaller invertebrates, creatures with relatively simple structure and function, get along without respiratory pigments. Their circulating body fluids can carry enough oxygen in aqueous solution. There are also transitional forms that possess hemoglobin, but use it only in an emergency. One of these is a tiny creature called the bloodworm, that actually is the larva of a midge, a minute fly. Bloodworms dwell in the mud at the bottom of lakes. So long as ample oxygen is available to them, the bloodworms rely upon simple solution to transport oxygen in their blood. But whenever the oxygen of their environment is sharply lowered, these animals bring their latent hemoglobin into play to make the best use of the scarce oxygen.

And colors in animals serve other essential functions in addition to that of transporting oxygen.

Bright Animals

The primary green of the plant world shows plainly on the outside; the forest wears its heart upon its sleeve. Not so the animal world; its primary red is hidden away inside each creature. Perhaps this is fortunate. Within the forest we are soothed by the murmur of "green" that surrounds us from the staid trees and other plants. Could we bear a world in which the animals, besides scurrying frenetically about as is their wont, also shrilled continuously "red! red! red!"?

H. Armstrong Roberts

The protective coloration of the grouse is so well contrived that the walker in upland forests is repeatedly startled when his approach causes a covey of these birds to explode from apparently a vacant spot.

But animals do have external colors, of great variety and often of great beauty. Animal colors either are due to pigments – sometimes made by the animals themselves but sometimes taken in with plants consumed as foods – or else are due to the physical structure of the external animal tissues.

This latter structural coloration is of two sorts: Tyndall scattering and interference of light. John Tyndall demonstrated almost 100 years ago that the color of the blue sky is caused by the fact that fine particles in the upper atmosphere scatter, toward earth, more short rays than long rays of sunlight. The blue of human blue eyes is similarly due to light scattering; such eyes contain no blue pigment whatsoever. Tyndall scattering is responsible for the hues of blue feathers and green feathers in birds. This fact may be demonstrated by viewing a blue or green bird's feather by transmitted rather than reflected light; it then appears to be colorless. Red or yellow feathers, in contrast, owe their colors to the presence of pigments, and retain their colors whether viewed by reflected or by transmitted light.

The other type of animal coloration due to physical structure is iridescence, just like that of oil films floating on water or of soap bubbles. Such colors are caused by destructive interference of monochromatic components of white light, reflected from two superimposed surfaces. Examples of interference coloration in animals are peacock feathers; wing colors of flies, of many butterflies and moths, and of some beetles; and the mother-of-pearl lining of mollusk shells. As colors from interference films change according to the angle of incidence of the light and the thickness of the film, the animals just listed provide an ever-changing display of, literally, every color of the rainbow.

A butterfly's wing may be used to demonstrate categorically the fact that many of its colors are due to interference. The films involved here are layers of transparent wing scales. A drop of ether placed on such a butterfly wing fills in the air spaces among the scales and causes the colors to disappear; then as the ether evaporates, the gorgeous hues promptly return.

The remaining external colors of animals are, like those of the yellow and red bird feathers just mentioned, caused by pigments. Prominent among these pigments are our old friends the carotenoids. The robin's red feathers, the canary's yellow feathers, and the yellow beaks of many birds are colored by carotenoids. So are the yellow component of the frog's green skin; the orange of the goldfish and of the newt's belly; the pink of salmon meat and flamingo feathers; the green and orange of some crabs and the lobster's blue-green shell and red antennae. In these latter crustaceans, the carotenoids are chemically united with proteins. That is why a lobster turns red when it is boiled. The protein of blue-green carotenoid-protein complex is coagulated by heat, and the remaining free carotenoid is red.

We have previously stated that animals cannot themselves make carotenoids, but must get these substances from plants. This dictum is confirmed by observation of external animal colors. Thus trout obtain the pigment for their attractive red skin spots

H. Armstrong Roberts

With his iridescent head and snowy white necklace, the male mallard duck would never be confused with his drab-colored mate.

from fresh-water shrimps; the shrimps in turn get the carotenoid involved from the water plants on which they subsist. If captive trout are fed a shrimp-free diet, their spots fade. Similarly, wild flamingos obtain the pink for their feathers by eating shrimps. If kept captive and not fed shrimps, the flamingo's feathers come in snowy white after the ensuing molt has taken place.

Homemade Colors

But some animal pigments can be made by the animal organism itself. Hemoglobin is an outstanding example. Hemoglobin is continuously manufactured (in human beings principally in the marrow of the long bones where, in each person, some 30,000 red blood cells are made every second) and is continuously broken down to bile pigments, and mostly excreted in this form. But some bile pigments are used for colorful purposes; one variety gives blue birds' eggs their hues, another makes the bones of the garfish green.

Any observant naturalist has noted that green is almost as common among insects as among plants; grasshoppers and caterpillars are well-known examples. The insects' green is not, however, chlorophyll taken in with their food, as originally thought. It is a mixture of a yellow carotenoid that is derived from the insects' foods, with a blue bile pigment the insects produce themselves.

Another pigment the animal body can manufacture is melanin. Melanin is responsible for the black parts of salamanders, the color of crows and of black cats, for suntanning of white men's skins and for the color of negroes' skins. But all is not black with melanin; this pigment is also responsible for blonde human hair and the golden fur areas of cat-family members such as the ocelot. Melanin is made, stepwise, from the amino acid tyrosine found in proteins, with the

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The Much Dreaded Red Cloak

Technology Alumni played a significant role in the conquest of typhus fever in Serbia

by JAMES A. TOBEY

In 1915 the final semester at M.I.T. was drawing to a close when an urgent telegram was delivered to Professor William T. Sedgwick, Head of the Department of Biology and Public Health. It came from Surgeon General William C. Gorgas; it asked how many expert sanitarians Sedgwick could recruit immediately for an important American Red Cross mission to Serbia. Sedgwick promptly answered that he thought he could furnish 10. Back came the reply, make it 15, and please make it fast. Sedgwick said he would, and he did, with help from Dr. Milton J. Rosenau of the Harvard Medical School and from George C. Whipple, Professor of Sanitary Engineering at Harvard and one of Sedgwick's first students, in the Class of 1889.*

Within two months or so a contingent of 26 physicians and sanitary engineers sailed on the *Athinia* for Serbia. Eleven of this carefully selected group were graduates of M.I.T., five more had taken work at the recently established (1913) Harvard-Technology School for Health Officers, two were from Harvard, and only eight represented other institutions. These public health experts were on their way to fight a wartime epidemic of a disease which always had been especially dangerous to those fighting it. In Serbia practically every doctor – only about 350 in all – had contracted the malady, and more than one-third (36 per cent) had died of it.

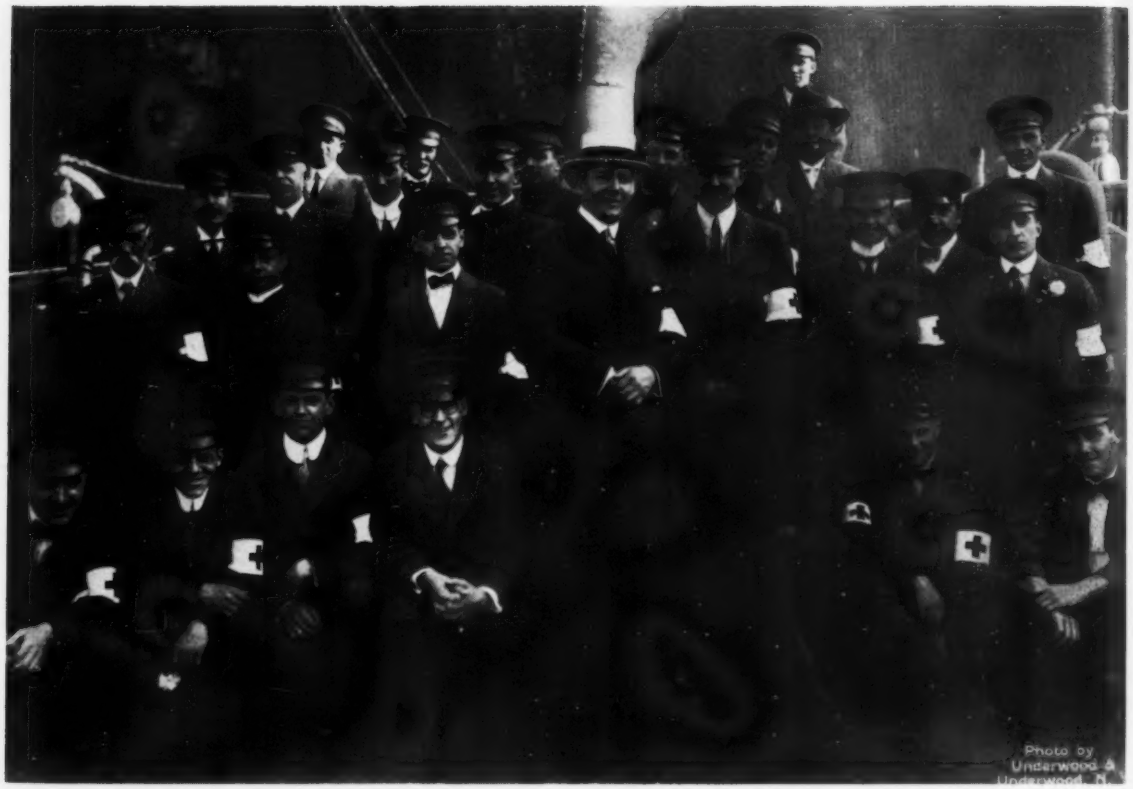
This dangerous disease was typhus fever, known in history as *El Tabardillo*, the Much Dreaded Red Cloak, so-called because of the characteristic red spots on the skin which resemble flea bites. The disease had begun to appear in the valiant Serbian Army in November of 1914 while it was engaged in repelling the invading troops of Austria-Hungary, an invasion which had launched World War I about two months earlier. In this first campaign the Serbs were victorious, taking about 60,000 prisoners, fully one-half of whom succumbed to typhus fever in December and January. Whether the Austro-Hungarians brought the disease with them and gave it to the Serbs, or vice versa, is an open question, but it is probable that this malignant fever had been lying dormant in both countries and that wartime conditions sparked it into flame. At any rate, 2,500 typhus patients were admitted daily to the Serbian military hospitals, and at the end of six months more than 150,000 persons in that country had died of the disease. The mortality in this outbreak was exceptionally high – rapidly increasing from 20 per cent to 60 per cent of the cases. The members of that American Red Cross mission earned the medals they eventually got.

During the six months of this epidemic, Serbia was practically helpless, with its army absolutely immobilized, but Austria-Hungary dared not attack, realizing that typhus was holding the borders. This delay was undoubtedly favorable to the Allies and may well have been a factor in their ultimate victory. It was not until the end of 1915 that Serbia finally was conquered by a combination of Germans and Bulgarians along with the Austro-Hungarians. As had happened so often before in the stream of history, typhus fever had been a potent factor in influencing the course of human events.

In response to an urgent plea for help from the Serbian government, the United States, which was then neutral, organized the American Red Cross Sanitary Commission, under the direction of Dr. Richard P. Strong of the Harvard Medical School. Among the half dozen or more of his immediate associates were Edward Stuart, an M.I.T. graduate in sanitary engineering in the Class of 1910, and Dr. Hans Zinsser, then of Columbia University, whose fascinating book, *Rats, Lice and History,*† brought him well-deserved fame in 1935. The American Red Cross and half a dozen other nations, including Russia, also sent out hospital units to care for the legion of the sick. Two of the American physicians in charge of hospitals contracted typhus and died of it, and a number of others were afflicted but recovered. Among other Americans involved in this epidemic was the late Lieutenant Colonel Edgar Erskine Hume of the Army Medical Corps who later, in 1921, took a public health degree at M.I.T.; as a brigadier gen-

*Dr. Stanley H. Osborn, '15, State Commissioner of Health of Connecticut since 1922, was one of Sedgwick's men in Serbia. He kept a most interesting diary of 264 typewritten pages, profusely illustrated, which it has been the writer's privilege to read. Copies of this invaluable document on the Serbian epidemic of 1915 are also in the libraries of M.I.T. and the American National Red Cross. Dr. Osborn lists the following M.I.T. men with the Red Cross mission to Serbia: George W. Bakeman, '13, Ralph D. Bates, '14, Henry E. Berger, Jr., '15, Dr. Albert W. Buck, '13, Dr. Carl E. Buck, '15, Dr. Albert F. Cornelius, '15, Charles E. Fox, '14, Elliot H. Gage, '13, Joseph E. Harrington, '12, Dr. Estus H. Magoon, '14, Dr. Ralph W. Mendelson, '15, Dr. Harold H. Mitchell, '16, Dr. Stanley H. Osborn, '15, and Edward Stuart, '10. Albert and Carl Buck, Albert Cornelius, Charles Fox, Elliot Gage, Joseph Harrington, and Edward Stuart are now dead. Dr. Mendelson later went to Siam, where he was physician to the king; during World War II he and the writer served together in military government in Europe.

†Boston: Little Brown and Company, 1935



From Dr. Stanley H. Osborn, '15, comes this interesting view of members of the American Red Cross Sanitary Commission to Serbia, mentioned in Dr. Tobey's article. The photograph was taken aboard the S.S. Athinia *on May 15, 1915. The seven kneeling or sitting in the front row are (left to right): Dr. Albert W. Buck, '13 (then inspector with the Massachusetts State Board of Labor and Industries); Ralph D. Bates, '14; Stanley H. Osborn, '15 (who received his C.P.H. from M.I.T. a few weeks prior to usual commencement activities); Henry E. Berger, Jr., '15; George W. Bakeman, '13, in shade (then engineer for the State Board of Health of Massachusetts); Charles E. Fox, '14 (then assistant sanitary engineer, State Board of Health of Maryland); and George H. Hazelhurst, graduate of Rensselaer Polytechnic Institute and Harvard University.*

Standing (left to right) are: E. D. Gayle (Sanitary Department, Isthmus of Panama); Francisco P. Bravo of Havana; Dr. Fleetwood Gruver of Nashville, Tenn.; George W. Taylor (Sanitary Department, Isthmus of Panama); Joseph E. Harrington, '12 (then graduate student at M.I.T.); Elliot H. Gage, '13 (then engineer for the State Board of Health of Massachusetts); Charles P. Crafts (Sanitary Department, Isthmus of Panama); Dr. Estus H. Magoon, '14 (then assistant in the Department of Civil Engineering at M.I.T.); Gerald F. Laughlin of Panama; Dr. Ralph W. Mendelson, '15, of Chicago; Major Robert U. Patterson, in straw hat (later Major General and Surgeon General, U.S.A., 1931-1935); Clement B. Chin (Sanitary Department, Isthmus of Panama); Edward Stuart, '10 (sanitary engineer for the Commission and on leave as Chief Engineer, State Board of Health of Oklahoma); Theodore R. Schoonmaker (sanitary engineer at Little Falls, N.J., and prior to sailing, at Baltimore, Md.); Dr. Carl E. Buck, '15 (then a special student at M.I.T.); Otis T. Campbell of Panama; Dr. Albert F. Cornelius, '15 (who, with Osborn, received his C.P.H. from M.I.T. in time to sail with awarded certificate); Dr. John S. Schmitt (then Acting Assistant Surgeon, U.S. Public Health Service); Dr. Harold H. Mitchell, '16; and Dr. Richard S. Lyman, '16 (in back of Mitchell and slightly to the right). Identification of persons was provided by Dr. Osborn, but professional affiliations, when known, were taken primarily from newspaper clippings of May, 1915.

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eral in World War II he fought typhus in Naples in 1944, and as a major general and chief surgeon of the Far Eastern Command under MacArthur he fought it in Japan and Korea.

By August of 1915 the Serbian epidemic of typhus had run its course. The disease probably had used up its quota of susceptibles; although basically a cold weather malady, undoubtedly its passing was accelerated by the efforts of the American Red Cross Sanitary Commission. Only six years earlier, in 1909, a French scientist at the Pasteur Institute in Tunis, Dr. Charles Jean Henri Nicolle, had demonstrated that typhus is disseminated by the body louse. The Serbian campaign, therefore, offered an opportunity for massive delousing, as well as for various other sanitary measures, which apparently were effective.

Although typhus waned in Serbia it traveled on to Poland, where it raged in 1916, and then passed on to Russia, whose army had been uniquely unsuccessful in World War I. After a disastrous retreat of the Russians in 1916, more than 150,000 cases of typhus were reported in that nation, but this was a mere drop in the bucket compared to what was to come. In the next five years, Russia is reliably estimated to have been devastated by no less than 25,000,000 cases

(Continued on page 96)

BUSINESS IN MOTION

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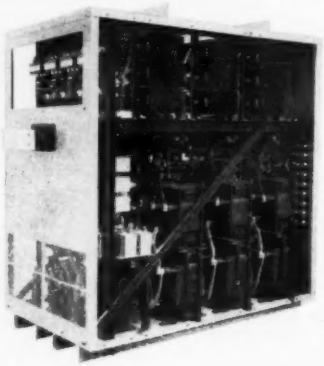

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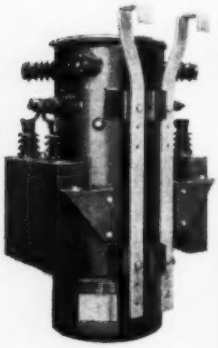

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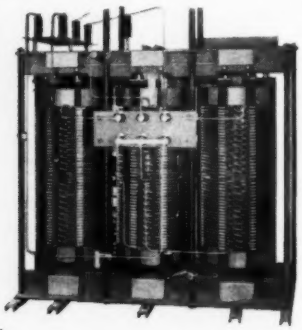

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MUCH DREADED RED CLOAK

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of typhus, with at least 3,000,000 deaths. The Bolsheviks who had come to power in 1917 did not seem to be interested in assistance, or interference, from outside. Poland, however, was not yet contaminated with Communism and cordially received a typhus research commission of the League of Red Cross Societies in 1920. Under the direction of Drs. S. Burt Wolbach and John L. Todd, this commission made some noteworthy studies on the cause of the disease, which had been determined in 1916 to be a virus-like organism known as *Rickettsia prowazeki*, so-called after the American, Dr. Howard T. Ricketts who died in Mexico City of typhus in 1910, and St. von Prowazeki, who died of the same disease in Germany about four years later. They were only two of half a dozen scientists who had succumbed to typhus while investigating it.

The Antiquity of Typhus

The great antiquity of typhus has been proclaimed by a number of eminent medical historians, although persuasive evidence of the existence of the disease before the Eleventh Century is more than meager. Some authorities claim to find references to typhus in Biblical accounts of the many afflictions of the ancient Hebrews, but most of these references are too vague to be of any real diagnostic value. Others profess to find in the description of Thucydides of the famous plague of Athens in 430 B.C. a definite indication of typhus, but that epidemic was much more likely to have been smallpox.‡ Some of the case reports of Hippocrates, written in the Fifth Century B.C. are alleged to be suggestive of typhus, but they are equally suggestive of a number of other maladies.

When my previously mentioned friend, General Hume, was librarian of the Army Medical Library in Washington, D.C. in the mid 1920's, he dug up for Dr. Zinsser what seems to be the first known reference to typhus. According to an Italian writer named Pratillo, there appeared at the Monastery of La Cava near Salerno, in the fall of 1083, a severe fever which differed from the Pest (bubonic plague) in that it was accompanied by *peticuli*, or spots, and swellings of the parotid gland. This ailment was probably typhus, but the strange thing is that nothing more is heard of the disease for about four centuries, when it burst into full bloom in Spain.

Granada, last stronghold of the Moors in Spain, was besieged by the armies of Ferdinand and Isabella in 1489, but was staunchly defended by the fiery brothers Muley Hassan and Ez Zagal. When Don Fernando reviewed his troops in 1490 he found that 20,000 of them were missing from the rolls; of these, only 3,000 had fallen before the swords of the Moors. The remainder had succumbed to a mysterious and malignant spotted fever, a highly fatal disease which was believed to have been brought by Venetian soldiers from the Island of Cyprus; they in turn had

(Continued on page 98)

‡Tobey, James A., "First Great Epidemic of History," *The Technology Review*, **58**:407 (June, 1956).

Progress Works Here

One of the most important and basic reasons for good telephone service is research. The many advances in speed, clarity, distance and convenience would not have been possible without it.

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MUCH DREADED RED CLOAK

(Continued from page 96)

acquired the malady from the Turks. This epidemic held up the Spanish conquest of Granada until 1492.

This epidemic also depopulated the whole Iberian Peninsula, raging intermittently for the next century. This series of early outbreaks was described in 1802 in a book on epidemic fevers by Joaquin Villalba, who said that the name *Tabardillo*, the Much Dreaded Red Cloak, was given to this pest in 1577 by one Luis de Toro, and that the disease was unknown before the siege of Granada. It was carried by the Spaniards to their newly acquired possessions in the Americas, where it ravaged Mexico City in the late Sixteenth Century. In 1570 the city physician there, Dr. Francisco Bravo, wrote a treatise on this spotted fever, which he called *Tabardete*. Until the end of the Eighteenth Century, when the name typhus (based on the Greek word meaning stupor) was adopted, the disease was known by a wide variety of names, including jail fever, famine fever, Hungarian disease, Irish ague, pipercorn, *hauptkrankheit* (head sickness), and so on.

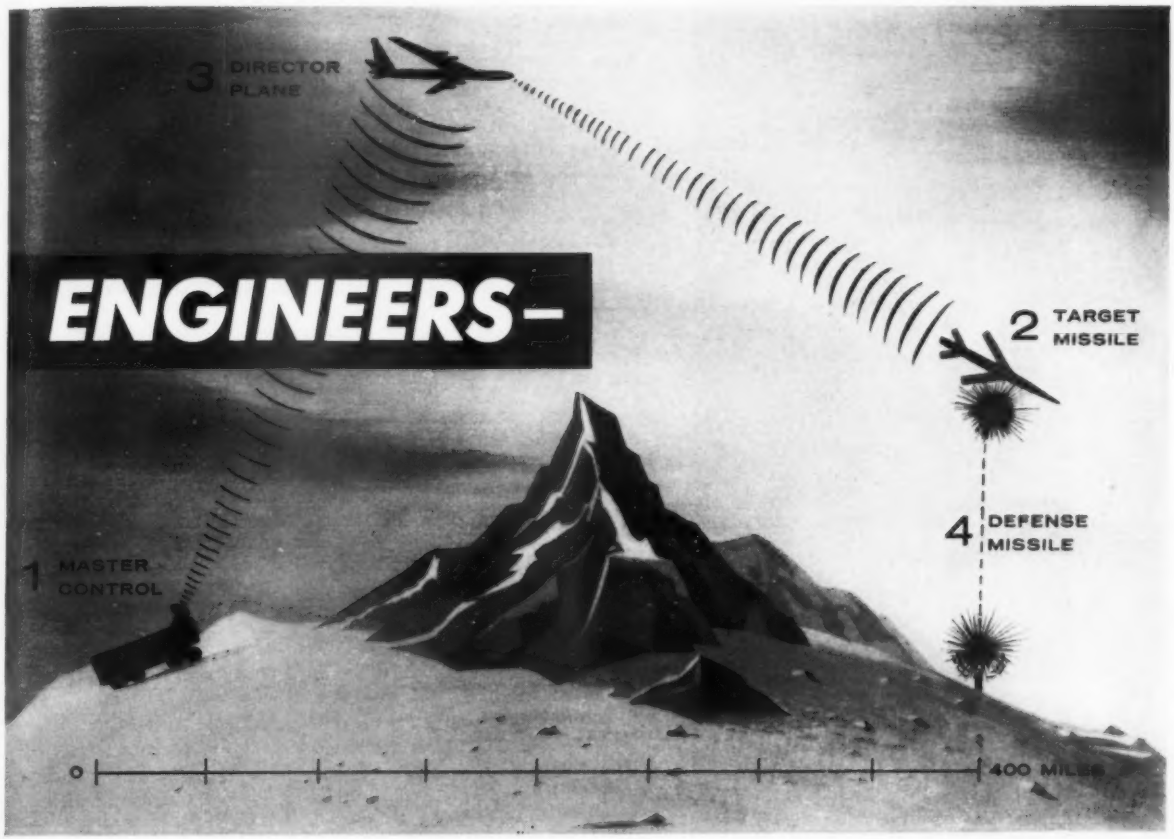
By whatever name it was known, typhus fever flourished all over Europe in the Sixteenth and Seventeenth Centuries. In 1528 a disastrous epidemic of this malady among the French troops at Naples enabled Charles V of Spain to emerge victorious from what had looked like a hopeless situation, and to get himself crowned as Roman emperor. In 1552, however, a terrible outbreak of typhus in his own forces at his siege of Metz balked Charles and compelled him to retreat. In 1566 the Emperor Maximilian II, son-in-law of Charles, marched into Hungary to do battle with the Turks, but his army was decimated by typhus, and the Hungarians had to continue to pay tribute to the Sultan. In the reign of Good Queen Bess in England, in 1577, typhus broke out following a trial at Oxford, killing the judge, the sheriffs, the bailiffs, and many of the spectators at this event, which came to be known as the "Black Assizes."

The Thirty Years War, from 1618-1648, which began as a religious conflict and ended as a political one, with Catholics and Protestants on both sides, was a series of massacres, sieges, and atrocities, invariably accompanied by famine and pestilence, in which typhus fever played a dominant part for the first 12 years, and then bubonic plague took over. In 1632, for example, when the gallant Gustavus Adolphus of Sweden was besieging Nuremberg, an epidemic of typhus, mixed with other diseases, caused 29,000 deaths on both sides. Fifty years later, in 1683, Austria was overwhelmed by typhus during the siege of Vienna by the Turks; here and in Hungary, the Balkans, and Russia the disease became so firmly implanted among the inhabitants that it remained to harass them down to, during and after World War I.

Napoleon and Typhus

This residue of typhus in Russia was one of the important factors in frustrating the grandiose schemes of a certain Corsican adventurer. In 1811

(Continued on page 100)



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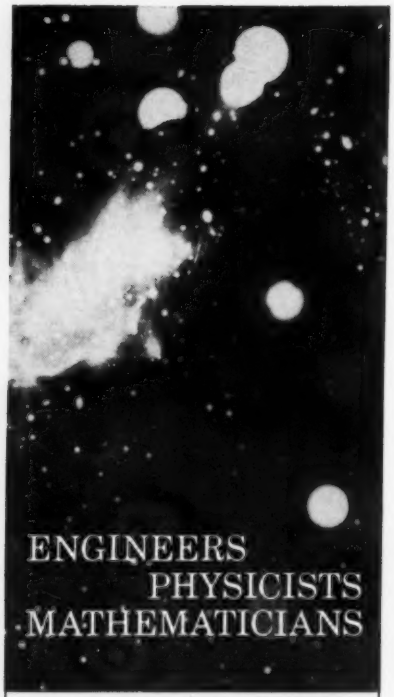

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MUCH DREADED RED CLOAK

(Continued from page 98)

the vainglorious Napoleon Bonaparte decided to invade Russia, assembling for this noble purpose a grand army of half a million men from 20 different nations. After a year of preparation, this huge force crossed the Niemen River in June of 1812 and started on the long road to Moscow. Bonaparte arrived there in September with one-fifth of the original army, to find the city in flames. On October 19 the return march began, leaving more than 15,000 sick and wounded in the military hospitals.

When the French Army staggered into Smolensk on November 9 it consisted of some 40,000 men, less than one-half of the force that had left Moscow; the rest had died on the way. At Vilna, on December 10, the fierce Cossacks swooped down and captured 30,000 of the ill-clad, half-starved soldiers who could go no farther; practically all of them died in prison of the jail fever. When Marshal Ney, the "bravest of the brave," finally delivered the remnants of this once grand army to Napoleon, who had left his troops in the lurch and returned secretly to Paris, it was literally a mere handful.

Historians attribute this disaster to the terrible Russian winter and the constant raids by the ferocious Cossacks, but that was only part of the story. Typhus fever, dysentery, scurvy, and other diseases took a tremendous toll of the unfortunate troops in this ill-fated venture. The Russians were not un-

(Continued on page 102)

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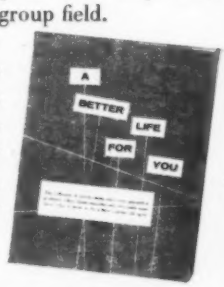

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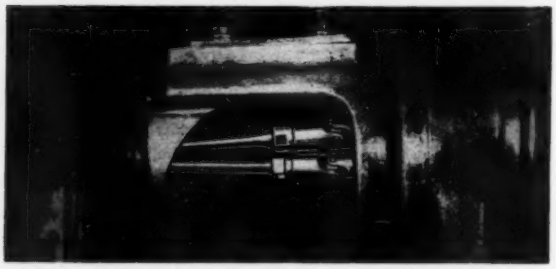

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MUCH DREADED RED CLOAK

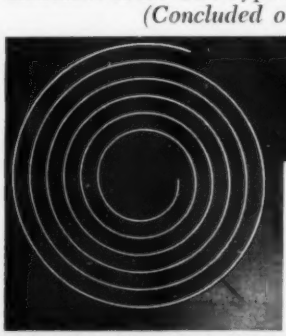
(Continued from page 100)

scathed, either; during their pursuit of the French, from October to December, it is reported that they lost 62,000 men from typhus, which they called the "nerve fever," and from other maladies. Nothing daunted by this inglorious defeat, Napoleon raised another grand army of 100,000 within a year, but things went badly and he ended in exile at Elba in 1814. He returned for a hectic hundred days, to be beaten by Wellington at Waterloo; he spent the remainder of his life at St. Helena, dying there in 1821, probably of an intestinal cancer.

Despite the great prevalence of typhus in Europe and the flow of immigrants to America, typhus never gained much of a foothold in the United States. There was an outbreak in Philadelphia in 1836, which was investigated by Dr. William W. Gerhard, who was the first to differentiate typhus from typhoid fever, a disease with somewhat similar symptoms but an entirely different cause, a bacillus which was discovered in 1884. Typhus, always rife in armies, played no conspicuous part in our Civil War, although a few hundred deaths from this cause were reported, possibly because of confusion with other diseases. In World War I, the presence among our troops of the ubiquitous cooties did not lead to the spread of typhus, although other ailments caused by Rickettsia, such as trench fever, were common. At the end of the Nineteenth Century, cases of a peculiar fever were noted among immigrants in New York and Boston, a fever which came to be known as Brill's disease. Subsequent investigations showed it to be a milder form of typhus, spread not by the body louse but by the rat flea and the rat louse.

Typhus fever was, however, responsible for a significant epidemic in Naples during World War II, which might have had serious consequences if it had not been brought under control. Cases began to appear in this crowded and damaged city in October of 1943, about the time when the Allied Military Government took over. By January of 1944, when I was there, more than 1,000 cases had been reported in the civil population. The higher military authorities, with characteristic ineptitude, did not realize the importance of this outbreak, but the military governor in Naples, the late General Hume (mentioned earlier in this article), was also a medical officer and he managed to convince even higher authorities that something had better be done, and quickly. With the assistance of the U.S. Typhus Commission, which had

(Concluded on page 104)



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MUCH DREADED RED CLOAK

(Concluded from page 102)

headquarters in Cairo, medical and sanitary teams were organized and put to work. During the winter of 1943-1944 more than a million verminous Neapolitans were dusted with the new insecticide, DDT, while careful case finding, isolation, and other measures were also adopted. By the end of March the epidemic had been vanquished. All American troops, by the way, had been immunized against the disease and thus were protected. If this outbreak had gotten out of hand, it might have had a substantial effect upon our military progress.

"Typhus," wrote Dr. Hans Zinsser in 1935, "is not dead. It will live on for centuries, and it will continue to break into the open whenever human stupidity and brutality give it a chance, as most likely they occasionally will. But its freedom of action is being restricted, and more and more it will be confined, like other savage creatures, in the zoological garden of controlled diseases."§ What Dr. Zinsser wrote nearly a quarter of a century ago is true today.

§Zinsser, Hans, *Rats, Lice and History*, page 301 (Boston: Little Brown and Company, 1935).

LIFE IS COLORFUL

(Continued from page 92)

aid of a specific copper-containing enzyme. Lack of this enzyme causes albinism, a condition not uncommon in vertebrates of all sorts.

There are at least several additional chemical groups – pterins, porphyrins, and others – that are important in the external colors of animals, but these can scarcely be described in a brief discussion like this one. Suffice it to point out that an external red color in animals may have as many as six different causes. Carotenoids produce reds in sea anemones, crabs, trout, and flamingos; hemoglobin gives earthworms their color. Pterins produce reds in butterflies and frogs; a porphyrin lends this color to some bird feathers; a substance called "echinochrome" makes sea urchins red. Finally, in beetles, red can be a structural color.

What's the Use?

The aesthetic value of the animal colors we have been discussing need not be belabored. But what is their utility? These colors, and the varied and in-

(Continued on page 106)

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LIFE IS COLORFUL

(Continued from page 104)

tricate patterns they provide, are useful in either of two ways: they can make an animal inconspicuous, or can make it conspicuous.

Colors and their patterns provide to animals a means of survival; the method of concealment from natural enemies known as "protective coloration." Thus the walker in upland forests is repeatedly startled when his approach causes a covey of grouse to explode from an apparently vacant spot. The plumage of these birds blends so perfectly with the woodland background that they are well-nigh invisible when they are motionless. Some creatures contrive a seasonal change in color to minimize visibility. The eastern varying hare, for example, has a drab summer coat that serves to conceal it in summer forest, but in winter has an immaculate white pelage virtually invisible against the snow. Protective coloration, though, is also achieved by confusing, as well as by concealing, body outlines. Thus the Malayan gecko has a brilliant stripe down the center of its back that makes it difficult to identify in its customary surroundings. This is called the "dazzle" principle of protective coloration.

Another principle of protective coloration is that of broken pattern, epitomized by the zebra. This beast is most active during the hours of twilight; and in such dim light its markings, that in a zoo cage appear flamboyantly showy, serve to conceal it very well. Finally, there is Thayer's principle of protective coloration. The artist Abbott H. Thayer was the first to point out that, since light in the forest usually comes from above, animals as dark on their tops as on their bottoms are made prominent by their shadowed undersides. But if the lower surface is appropriately lighter than the back, unevenness in lighting is offset and the animal blends into its background. Thayer's principle may be demonstrated by noticing how many mammals, birds, reptiles, amphibians, and insects have underparts lighter than their backs. So much for the value of color in making animals less conspicuous; what about the reverse?

Sex in Technicolor

If this article had been prepared for a periodical of general circulation, it probably would have been advisable to capture the readers' interest by putting a little sex into the opening paragraphs. As it is, we

(Concluded on page 108)

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LIFE IS COLORFUL

(Concluded from page 106)

do not reach this topic until our conclusion. For color as a secondary sexual characteristic, and its importance in mating and reproduction, is the final phase of this discussion.

A leading humorous magazine once published a cartoon showing two turtles meeting and one saying to the other, "I'm a girl." This dilemma would never face, say, the mallard ducks, for the male of this species with his iridescent head and snowy white necklace could never be confused with his drab-colored mate. Color is a big element in the courtship displays of some animals. The peacock puts on a famous show. Even the lowly pigeon makes the most of his limited spectrum by puffing up his throat and spreading his tail. When the male man-of-war bird makes love he inflates dazzingly red throat pouches, and the male prairie chicken makes similar use of bright orange air sacs.

The carotenoids, on which we have touched so many times, are found in high concentration in the reproductive organs of numerous animals and plants; in eggs, in gonad glands, in pollen, in fruits. Whether the carotenoids serve any direct function here is not known; they may accumulate in sexual organs simply because these organs are high in fat, and carotenoids are fat soluble. Whether useful or not, the carotenoids produce some dramatic displays in connection with reproduction. The brilliant blue of barnacles, as already mentioned, is located in the gonads of these creatures. When a particular snail spawns, the male gonads turn a brick red while the female gonads lose carotenoids and become pale.

Thus it seems abundantly clear that without its myriad colors, life would not just be dull — it would be impossible.

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Mr. HAROLD W. McKNIGHT NEW YORK LIFE AGENT

at DAVENPORT, IOWA

BORN: May 4, 1909.

EDUCATION: Iowa State Teachers' College, B.S., 1934; M.S., 1948.

PREVIOUS EMPLOYMENT: Principal, High School—September, 1935—June, 1941. Industrial Arts Teacher and Audio Visual Coordinator, September, 1941—June, 1954.

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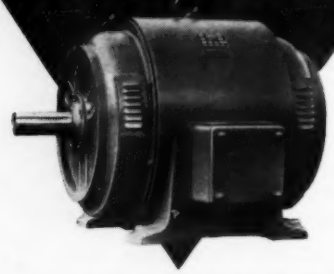

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TREND OF AFFAIRS

(Continued from page 82)

they went down fighting. No coach could ask more of a team than that.

Lacrosse

Despite bad weather which limited our practice, we won our first game – a scrimmage with St. Marks – by one goal, 8-7. What we lacked in practice and ability, we made up with enthusiasm and drive. The entire season was marked with steady improvement and development of fundamental skills, and in the later games, we were an integrated team, not just a group of boys. The team developed a unity which served it well in making this the most successful season ever for freshman lacrosse at M.I.T., having won more games than we lost. The record was 5-4.

Some of the outstanding games were the 7-6 loss to Harvard, the 12-0 defeat of New Hampshire, the 8-3 defeat of Tufts, the excellent game played against Andover, holding them to a 3-2 score in the first half, before the roof fell in – 11-3 final score. The game against Lawrence Academy, played in the pouring rain, was a thriller. It was an overtime game, the final and winning goal being scored in the last minute of the second overtime period. A most exciting game and a good win, 10-9.

There is no question in my mind that this freshman team will add substantial strength to the varsity next

(Continued on page 112)

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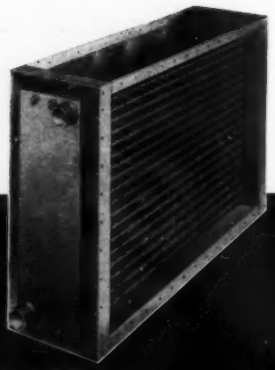

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TREND OF AFFAIRS

(Continued from page 110)

year. As a coach, it has been a most satisfying experience, and as a team, I could not have hoped for better results; the improvement, skill, enthusiasm, and spirit shown throughout the season were very gratifying.

Tennis

The 1958 M.I.T. tennis team opened its season with a southern trip during spring vacation. Matches were played against Quantico, Wake Forest, Maryland, and Howard. The southern trip affords the players a good chance to prepare for the season in a relaxed atmosphere without the pressure of daily school work.

After our return from the South, we had our first match against a very strong Harvard team. I feel that special mention should be made of our matches with Williams, Wesleyan, and Dartmouth. We lost to Williams 7-2, but did very well in winning the Number One Doubles and the Number Four Singles. Against Wesleyan and Dartmouth we lost 9-0 and 8-1, but the matches were closer than the team score indicates, as many of the individual matches were quite close.

The team showed a definite improvement over last year despite the loss of Richard H. Hough, '58, our Captain-Elect and Number Two man. The new

(Concluded on page 114)

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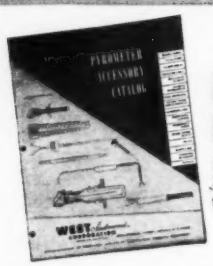

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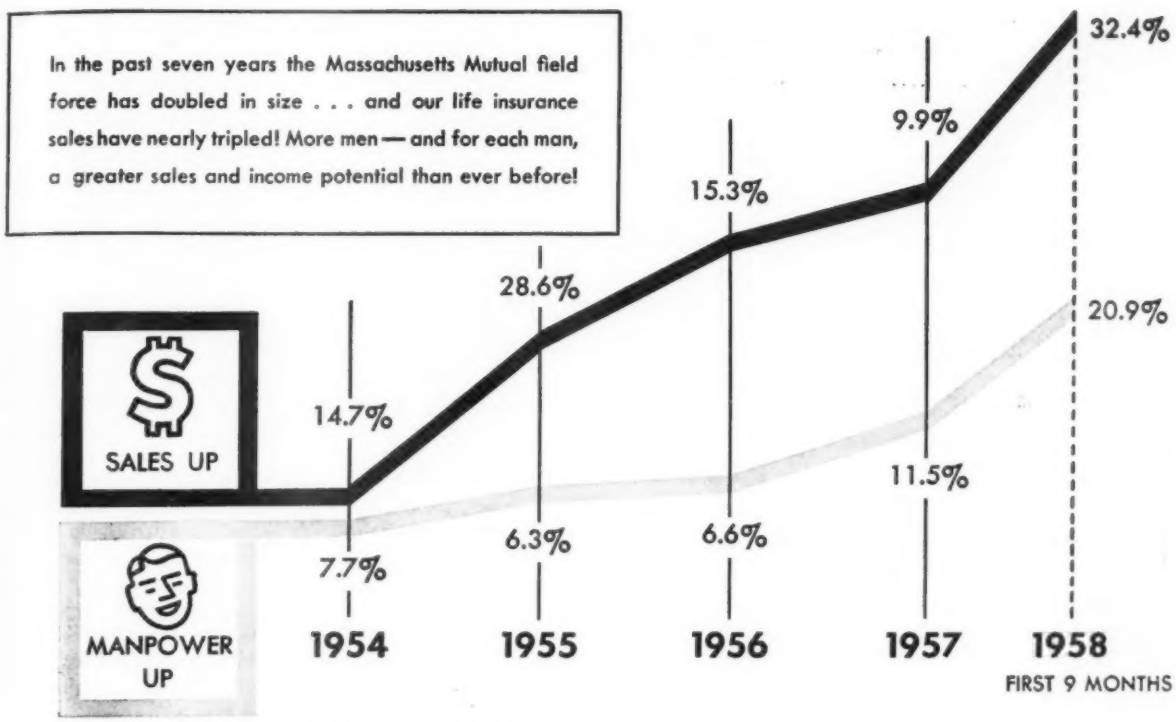

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TREND OF AFFAIRS

(Concluded from page 112)

courts are largely responsible for our improvement, as we were able to practice much more efficiently.

On May 16, 17, and 18 the New England's were held at Brown, and M.I.T. sent four men: Jeffrey H. Winicour, '59, Robert A. Kenefick, '59, Thomas M. Cover, '60, and David A. Aaker, '60. All of our players lost in the first round of the Singles.

Track and Field

With his 36th year at M.I.T. coming to a close, a well-rewarded retirement awaiting him, the M.I.T. track team did its best to earn a victory for Oscar F. Hedlund, but to no avail. But, as Oscar has said so many times, "the victories are fine, but the over-all number of boys taking part is more important."

The varsity lost meets to such worthy opponents as Northeastern, Tufts, Williams, Brown, Bowdoin, and New Hampshire. The caliber of track has increased greatly in New England so there is no disgrace in these losses. The freshmen, however, were able to put together four wins over Moses Brown, Northeastern, Governor Dummer, and Tufts, and lost three close-scoring meets to Brown, New Hampshire, and Andover.

Captain Glenn E. Bennett, '58, William F. Duffy, '59, and Larry R. Martin, '60, were the point winners in the middle distances for the varsity. Roxy E. Ernsberger, '58, Larry W. Lassinger, '58, and Edwin C. Bell, Jr., '58, took charge of the high and low hurdles. Richard L. Murdock, '58, one of New England's best, did very well in the 440. The two-milers were Roderick D. Swift, '58, and Duncan Ewing, '58. Nathan A. Liskov, '60, Robert P. Barrett, '60, two sophomores, and senior Thomas A. McClimans, '58, all scored heavily in the pole vault. The weight men who carried the load all the way were James R. Long, '60, Gary J. Fallick, '58, and Captain-Elect William J. Nicholson, '60.

Outstanding for the freshmen were Donald G. Morrison, '61, Dan R. McConnell, '61, Garrick A. Gustafson, 61, George L. Withbroe, '61, Richard F. Otte, '61, Raymond B. Landis, '61, Herbert Wegener, '61, Herbert H. Grieves, '61, Brian E. White, '61, Harold G. Snyder, 61, Mannie Smith, '61, and Captain Joseph T. Davis, '61. The varsity awaits them.

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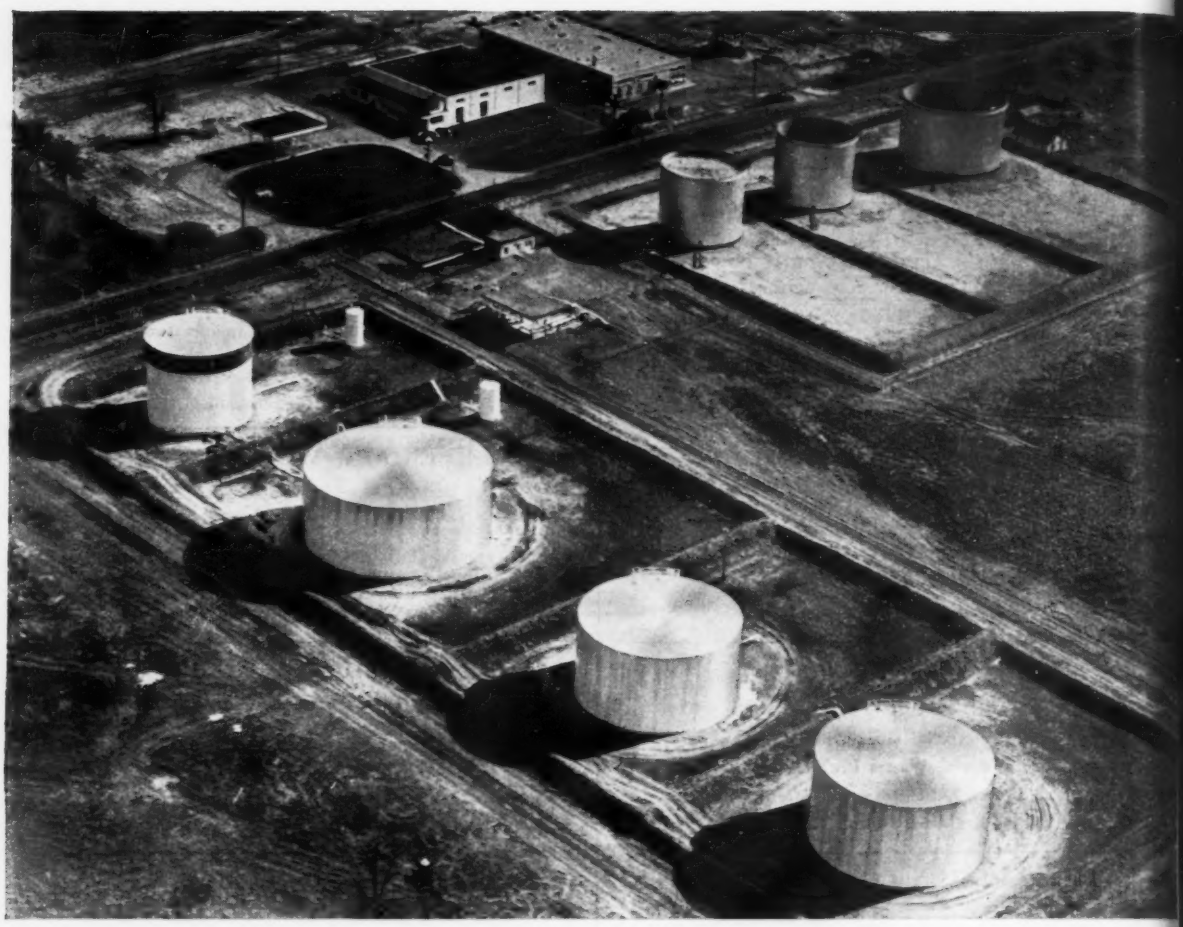

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The terminal in the background stores gasoline where pumping in and pumping out are almost daily procedures. For such operation, the owner wisely selected three Graver Double-Deck Floating Roof Tanks to combat vapor losses during frequent fillings and emptyings.

In the terminal in the foreground, storage was planned for marketing a variety of products. The Graver Expansion Roof® Tank at the left and the large cone roof tank manifolded to it preserve the volatility of stored gasoline during less frequent turnovers. The two smaller cone roof tanks hold kerosene and fuel oil.

These two adjacent terminals meet two quite different marketing requirements, yet both embody Graver's tested and proved designs for vapor-saving, profit-saving tankage. If you are planning new or enlarged terminal facilities, it pays to plan with Graver.

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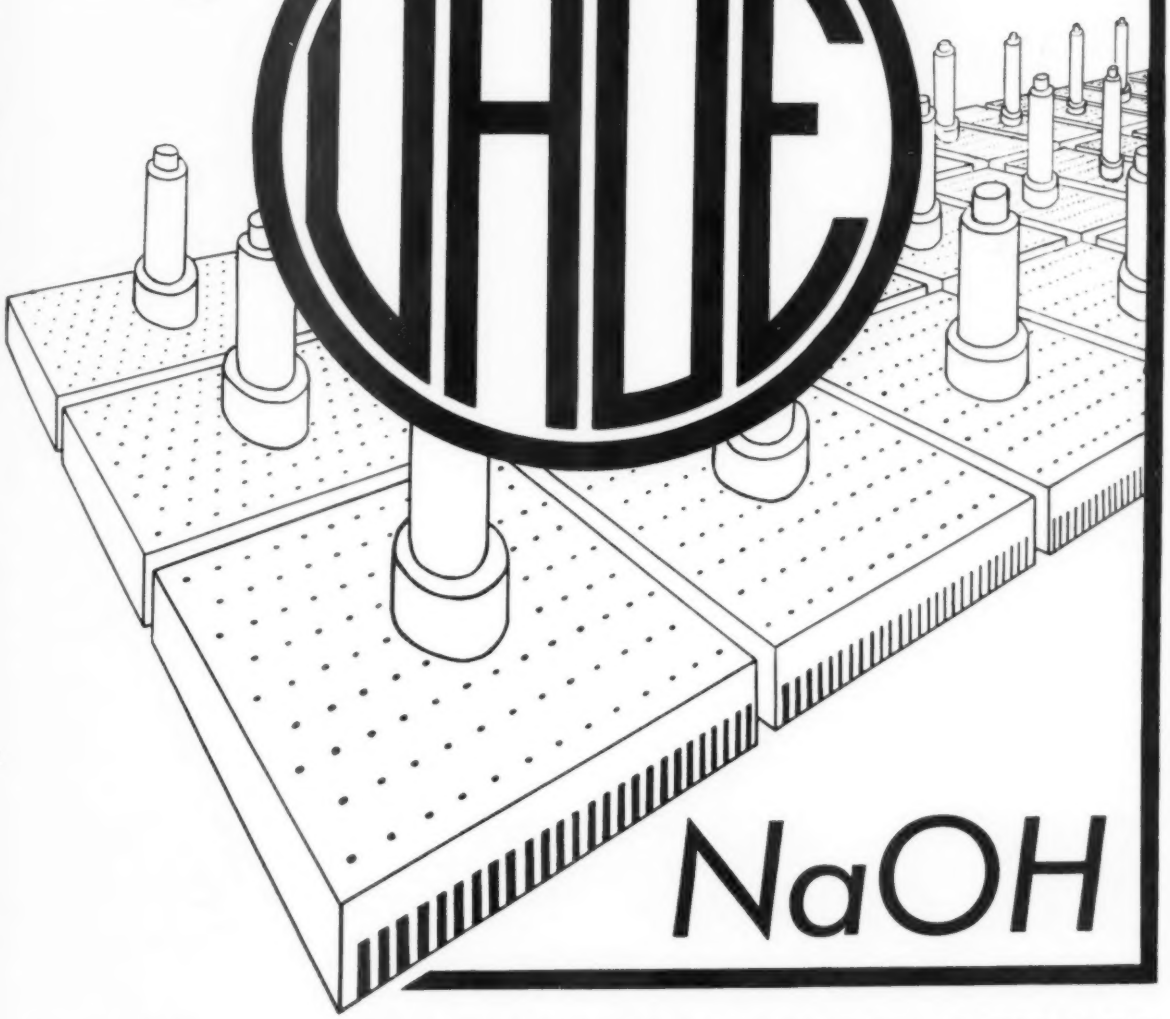

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THE *UHDE CORPORATION*

350 FIFTH AVENUE, NEW YORK 1, N.Y.
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5-lb. Frequency Standard

Headphones or oscilloscope, plus ¾ square feet of your bench are all that is needed for accurate and rapid frequency and time calibration with this G-R secondary standard of frequency. But don't let the small size fool you — this miniature standard contains all that's necessary for the precise calibration of oscillators, receivers, frequency meters, delay lines, and signal and pulse generators to frequencies above 1000 Mc. In addition, sweep-time standardization of oscilloscopes is easily performed at intervals from 0.1 μsec to 100 μsec.

This one instrument provides:

★ *Accurate 10-kc, 100-kc, 1-Mc, and 10-Mc fundamentals . . . plus harmonics to above 1000 Mc.*

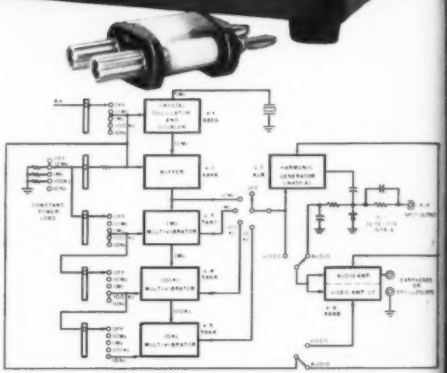
★ *An improved crystal mixer that combines performance with compactness, and protection for the crystal diode against surges.*

★ *Audio and video amplifier stages . . . to amplify beats from the mixer for frequency calibration, and to amplify the crystal-controlled multivibrator square waves for time calibration.*

The instrument's square-wave output, husky enough to trigger most pulse generators, can be converted to time markers for time calibration, by means of the G-R Type 1213-P1 Differentiator (supplied).

The Calibrator's crystal oscillator can easily be set to zero beat with an external standard such as WWV for accuracy much greater than required in most applications. A touch-button frequency deviator on the panel, which reduces frequency, permits you to determine quickly whether the crystal oscillator frequency is above or below WWV (or an unknown frequency to be measured).

By simply feeding an interpolation frequency into the Calibrator's mixer, along with the unknown signal, you do not restrict yourself to measurements at harmonics of the calibrator's fundamentals. Measurement or standardization at *any* frequency from 10 kc to above 1000 Mc becomes possible, including, for example, the setting of any television transmitter to its assigned frequency to within ±100 cycles or better. To illustrate: for an assigned frequency of 567,250 kc (Channel 30, visual), the interpolation frequency is 7,250 kc; or 2,750 kc, i.e., 560 + 7.250 Mc, or 570 — 2.750 Mc. By this simple interpolation technique, a broadcast station *on any channel* can perform its own frequency checks on visual, aural and color-subcarrier frequencies, as well as performance checks on all equipment including monitors.



SPECIFICATIONS

OUTPUT FREQUENCIES: 10 kc, 100 kc, 1 Mc and 10 Mc; harmonics usable to 10 Mc, 100 Mc, 500 Mc and 1000 Mc respectively.

NARROW-RANGE FREQUENCY ADJUSTMENT: 2.5 ppm variation (25 cycles at 10 Mc). For standardizing crystal oscillator against external signals.

TOUCH-BUTTON FREQUENCY DEVIATOR: introduces a momentary 1.8 ppm frequency decrease for establishing "sense" in indications near zero-beat.

OUTPUT AMPLITUDES: 10v peak-to-peak on 10-Mc output from pulse amplifier; 30v p-to-p at lower frequencies.

OUTPUT IMPEDANCES: 300Ω from video cathode follower; capacitively coupled r-f output from crystal-diode harmonic generator.

STABILITY: 1 ppm/°C after one hour warm-up with Type 1201 Regulated Power Supply.

SENSITIVITY: usable beat notes produced with 50-mv signal input to mixer.

Type 1213-C Unit Time/Frequency Calibrator, supplied with **Type 1213-P1** Differentiator.....$2[illegible]

Type 1201-B Unit Regulated Power Supply.....$[illegible]

Type 480-P4U3 Relay Rack Panel, for mounting both Calibrator and Power Supply.....$10.[illegible]

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